Measuring Fault Parameters and Slip from Geodetic Imaging Data using GeoGateway Online Tools

Geological Society of America 2020 Workshop
NASA Data Made Easy: Getting Started with Synthetic Aperture Radar

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GEO GATEWAY

GeoGateway Overview

- Online tools for analysis, modeling, and response using geodetic imaging data
- Main application of GeoGateway is to analyze and model crustal deformation related to earthquakes, and measure fault slip
- Focus of tools
  - Airborne InSAR data from NASA's airborne UAVSAR platform
  - Global Navigation Satellite System (GNSS) position time series, displacements, and velocities

- Other tools
  - Data layering
  - Faults
  - Seismicity
  - Forecasting
  - Modeling

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Data types and products

UAVSAR: NASA's L-band InSAR platform

- cm level detection of surface deformation
- Has measured
  - Landslides
  - Levees
  - Subsidence
  - Earthquakes
  - Volcanoes
  - Wildfire scars
  - Glaciers

GNSS: Global Navigation Satellite System

- Precise position time series
- Daily to sub-daily solutions
- Accuracies are sub-mm globally
- Provide rates to better than 1 mm/yr
- Limitations
  - Stations widely separated by 10 km or more
  - Difficult to infer smaller scale processes

Other Data Products

- UCERF-3 faults
- Seismicity
- User generated KML overlays

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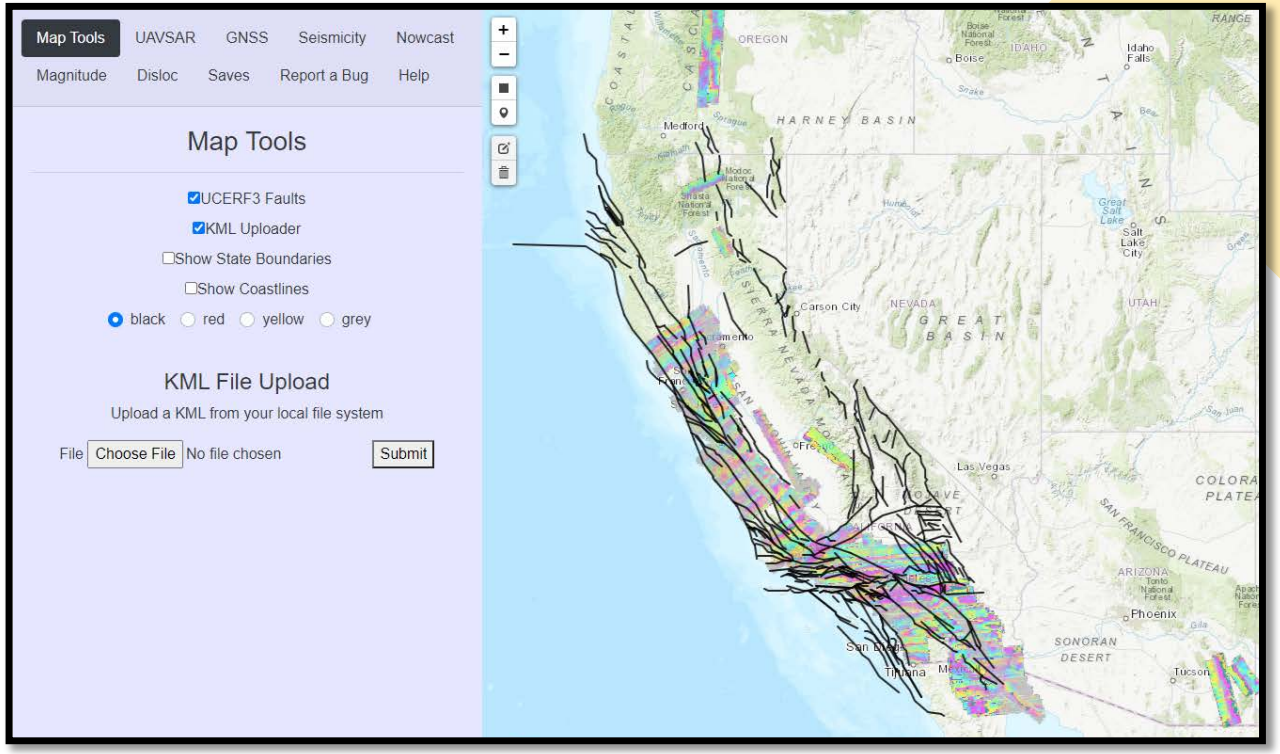
Geographic Coverage

- Global
- Focus on California
  - Majority of UAVSAR flights
  - UCERF-3 digitized faults
  - Abundance of GNSS stations
  - Dense Seismic Network



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Limitations

Limitations

- Advantages:
  - Designed for rapid analysis of geodetic imaging data
  - Allows for context from other data types
- Not suitable for full analysis
  - Can download products for further analysis
- Uncertainty quantification is limited
- No stacking of InSAR products (yet)
- User workspace is limited (so far)
- Possible bugs – please file feedback reports!

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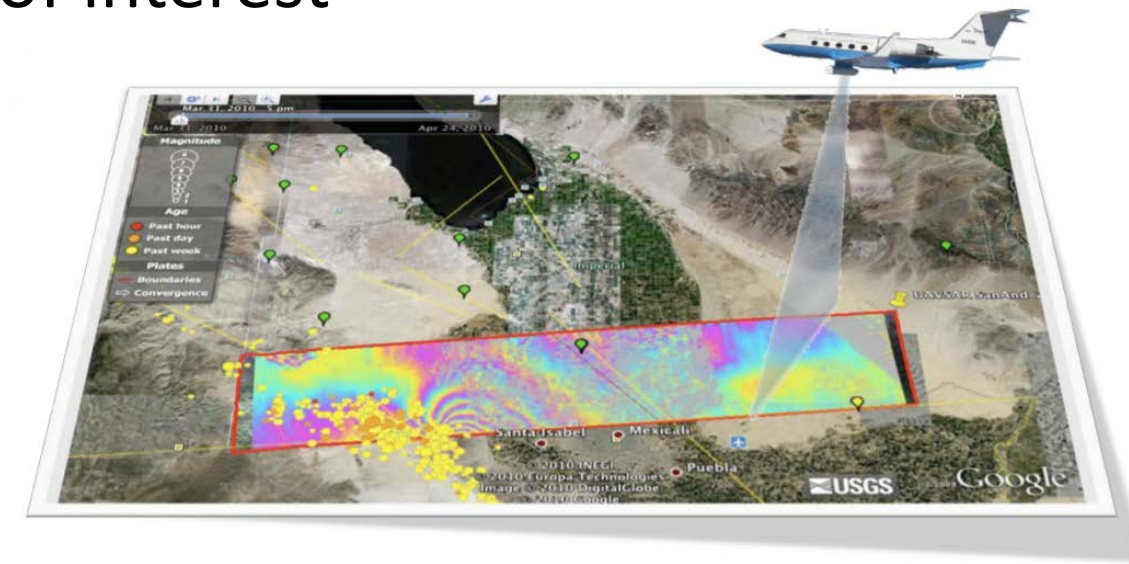
Uninhabited Aerial Vehicle Synthetic Aperture Radar

UAVSAR

- An airborne, L-band, fully polarimetric radar, housed in a pod that is mounted to the belly of a piloted Gulfstream III aircraft
- Interferometric radar images, or interferograms, are generated from repeat passes flown over a site of interest
- Interferometric radar observations are made from the swaths received, which are approximately 22 km wide and typically between 100 and 300 km long



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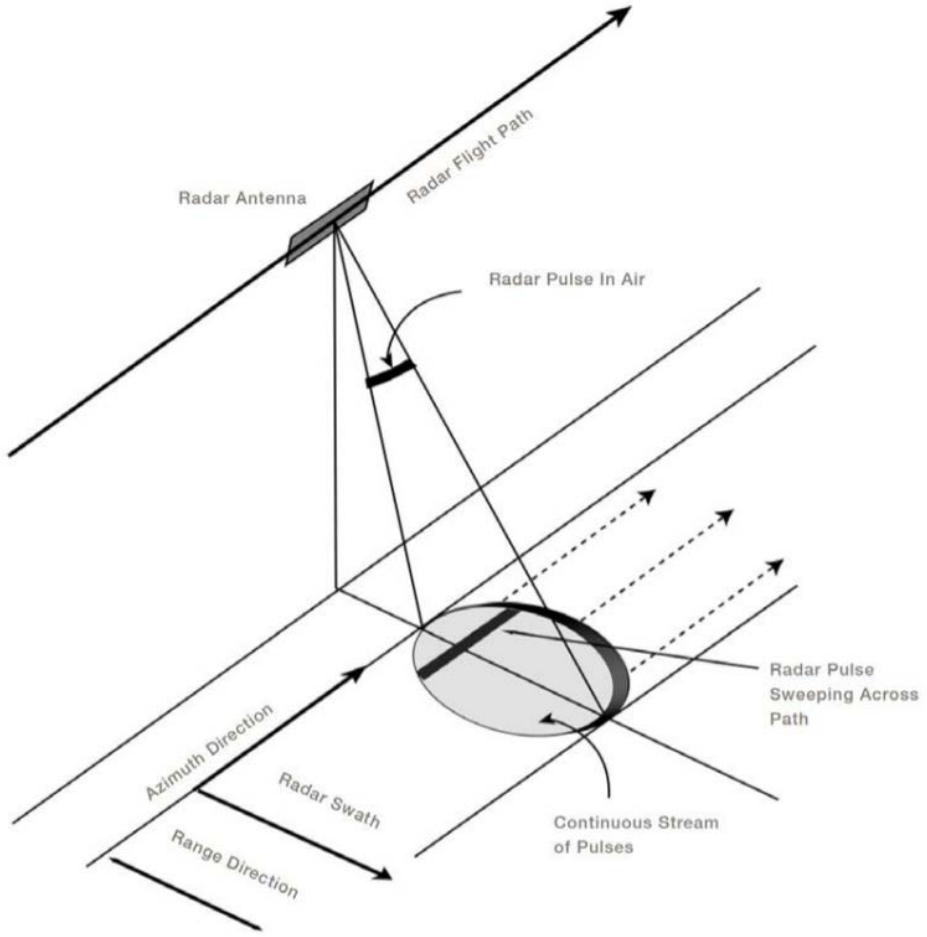
Basic InSAR Concepts

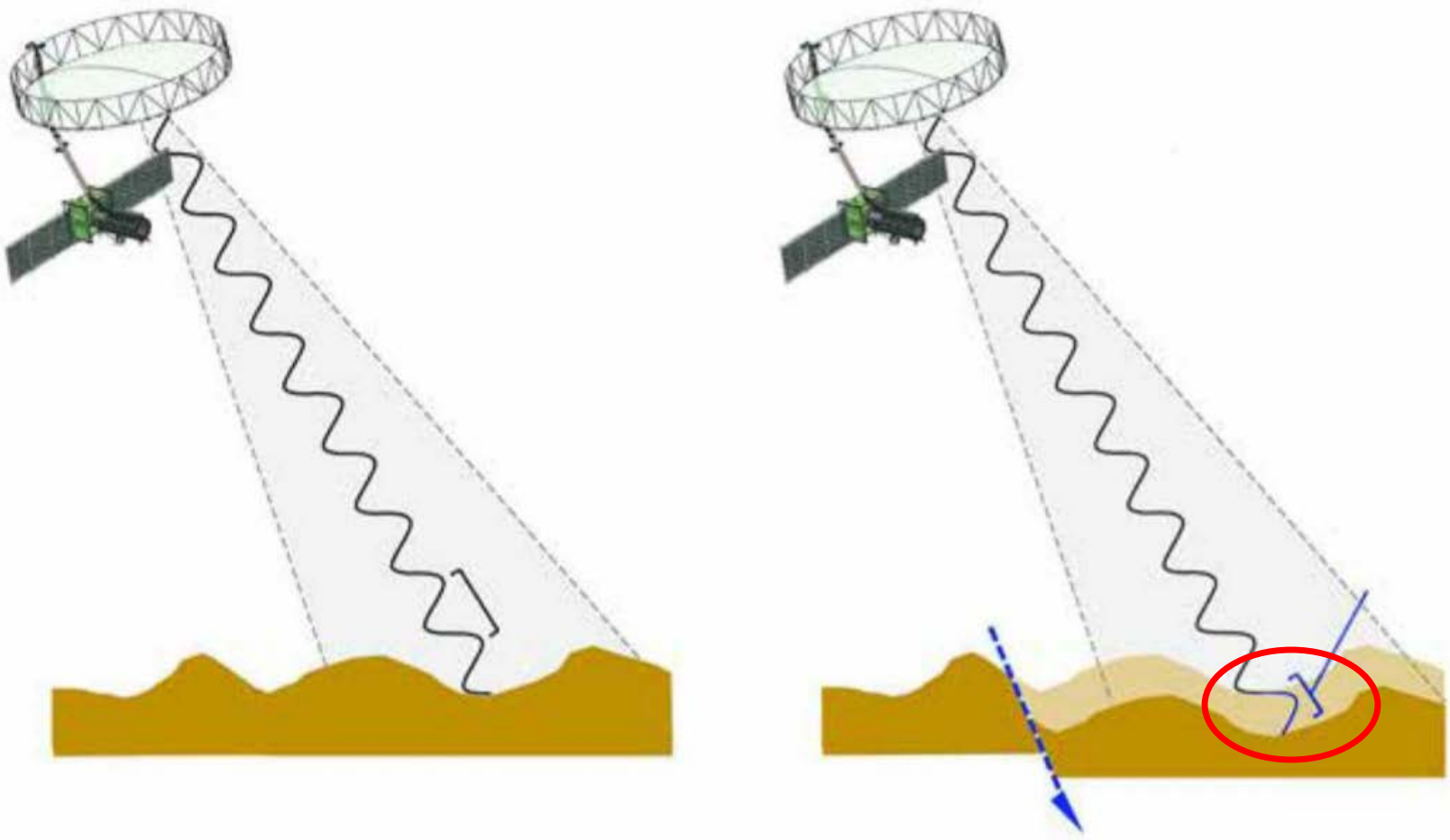
Basic InSAR concepts

- Selecting data products
- Displaying individual lines
- Color mapping
- Line of sight tool
- Downloading products
- Example from User Guide

Synthetic Aperture Radar

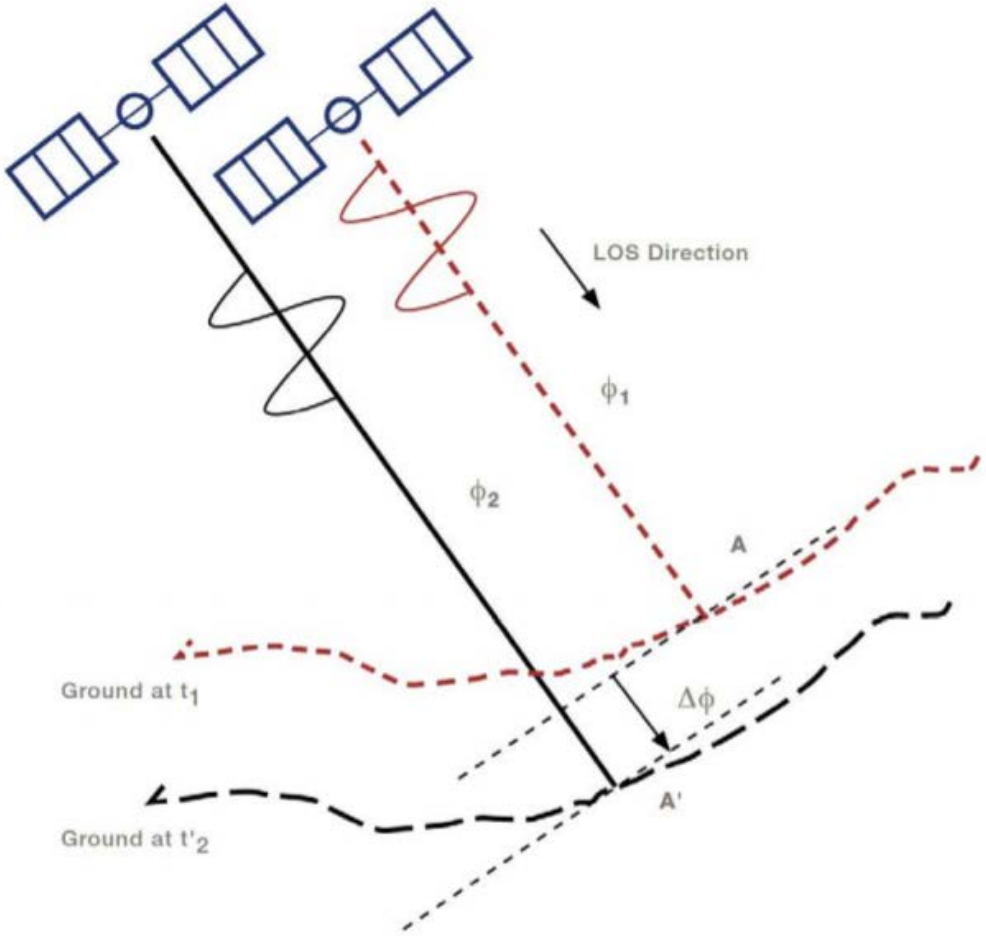


InSAR Phase Difference



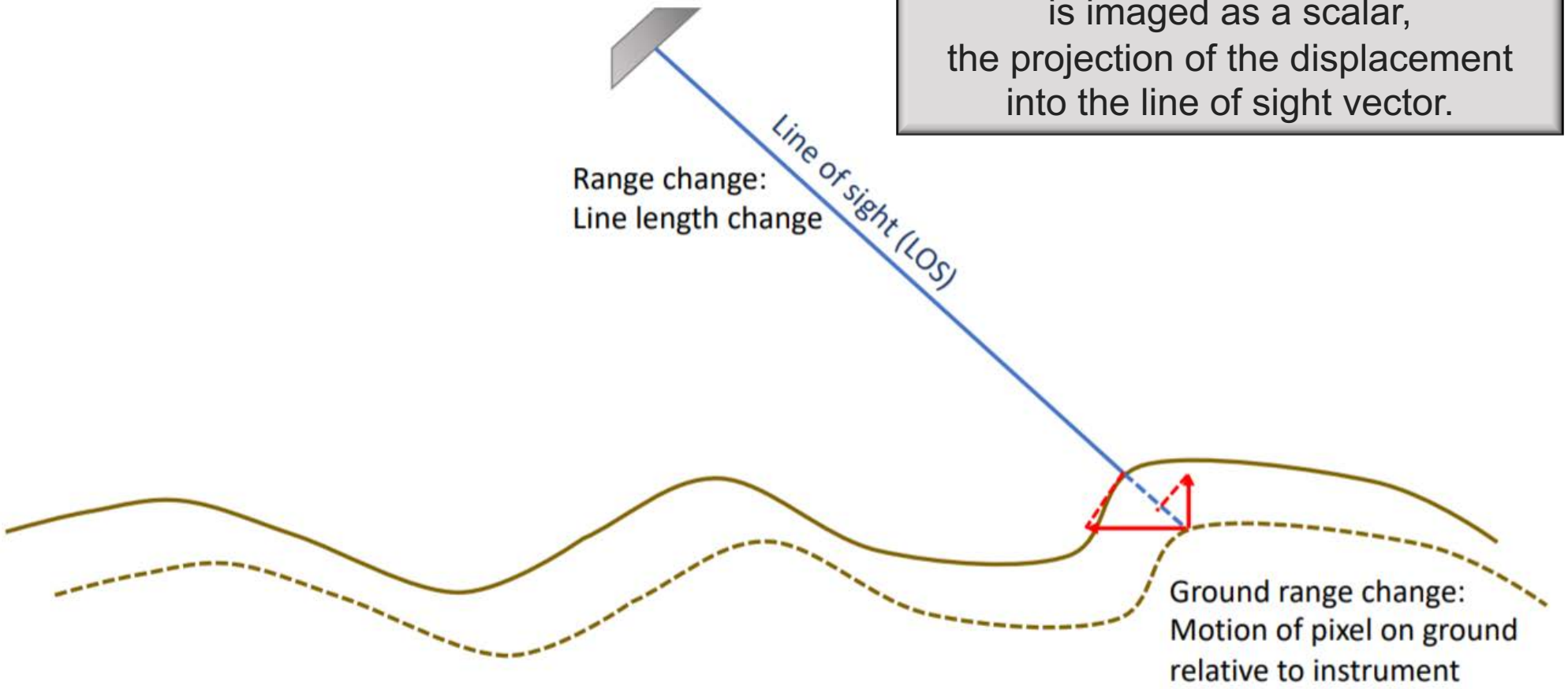
Phase Difference

- UAVSAR raw image pairs 1 m resolution
- UAVSAR unwrapped products 7 m



Line of sight (LOS)

Each pixel's 3-D displacement vector is imaged as a scalar, the projection of the displacement into the line of sight vector.

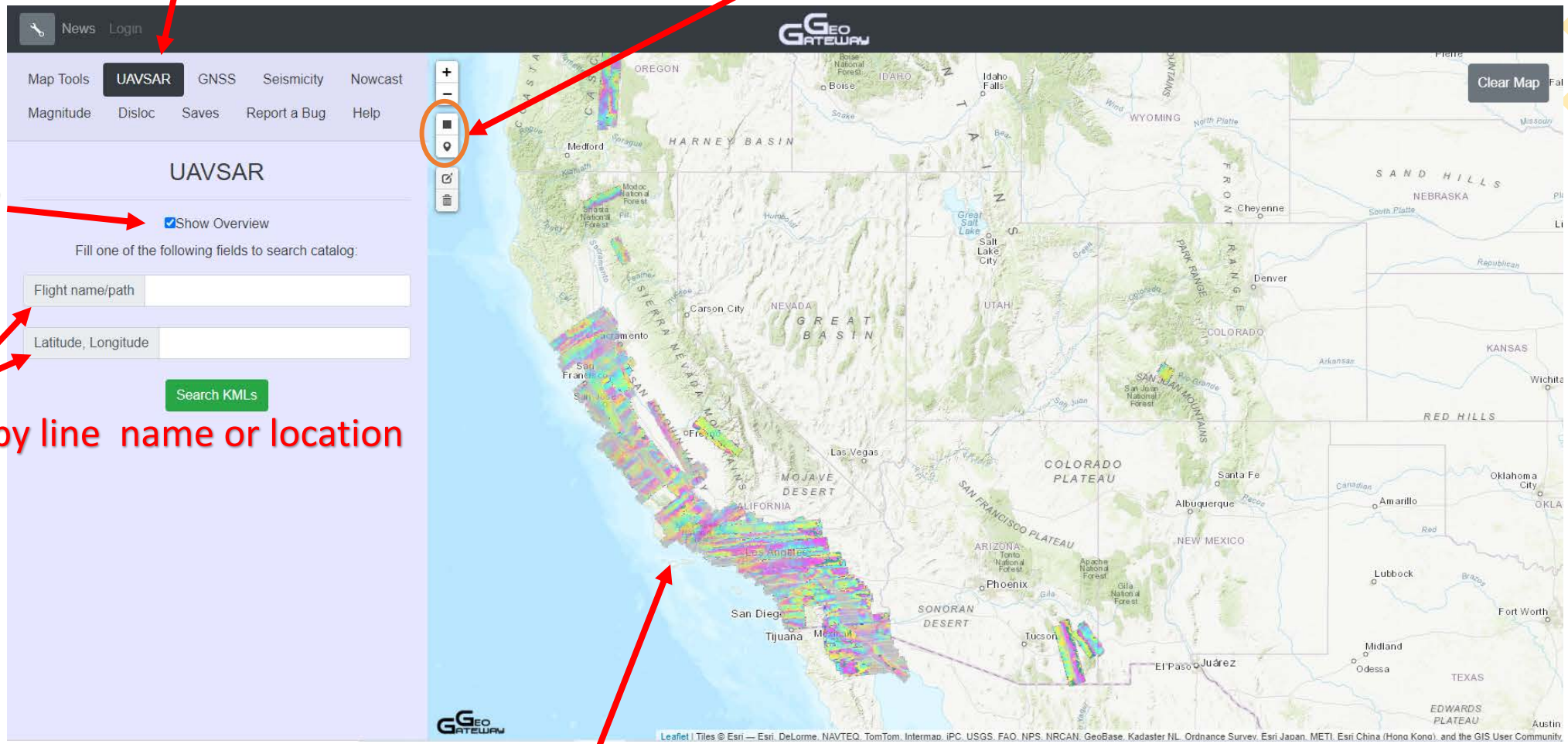


Select Data Products

1. Click on UAVSAR tab

4a. Select by point or rectangle

2. Check Show Overview



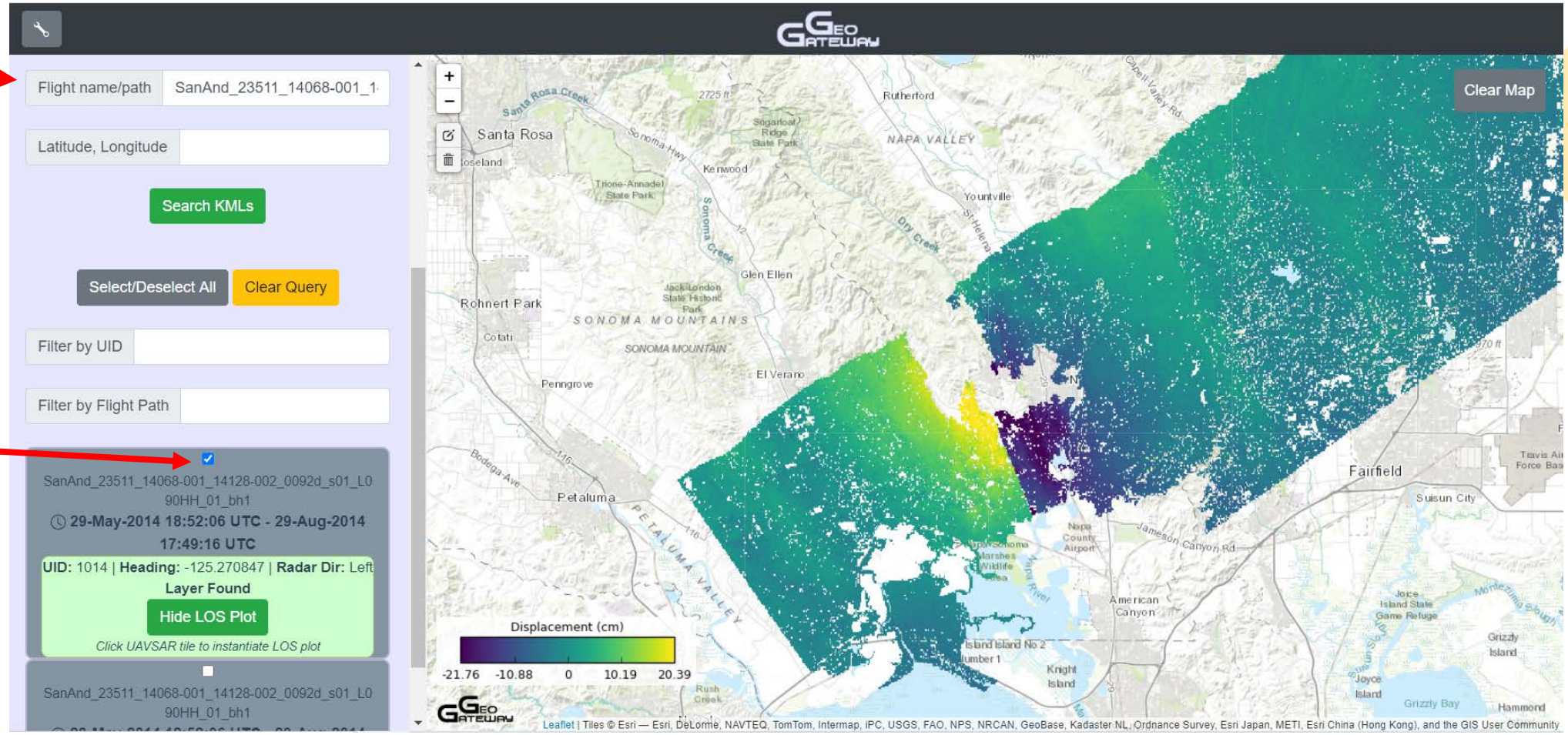
4b. Select by line name or location

3. Available products are displayed

Displaying Individual Lines

Select by flight name/path

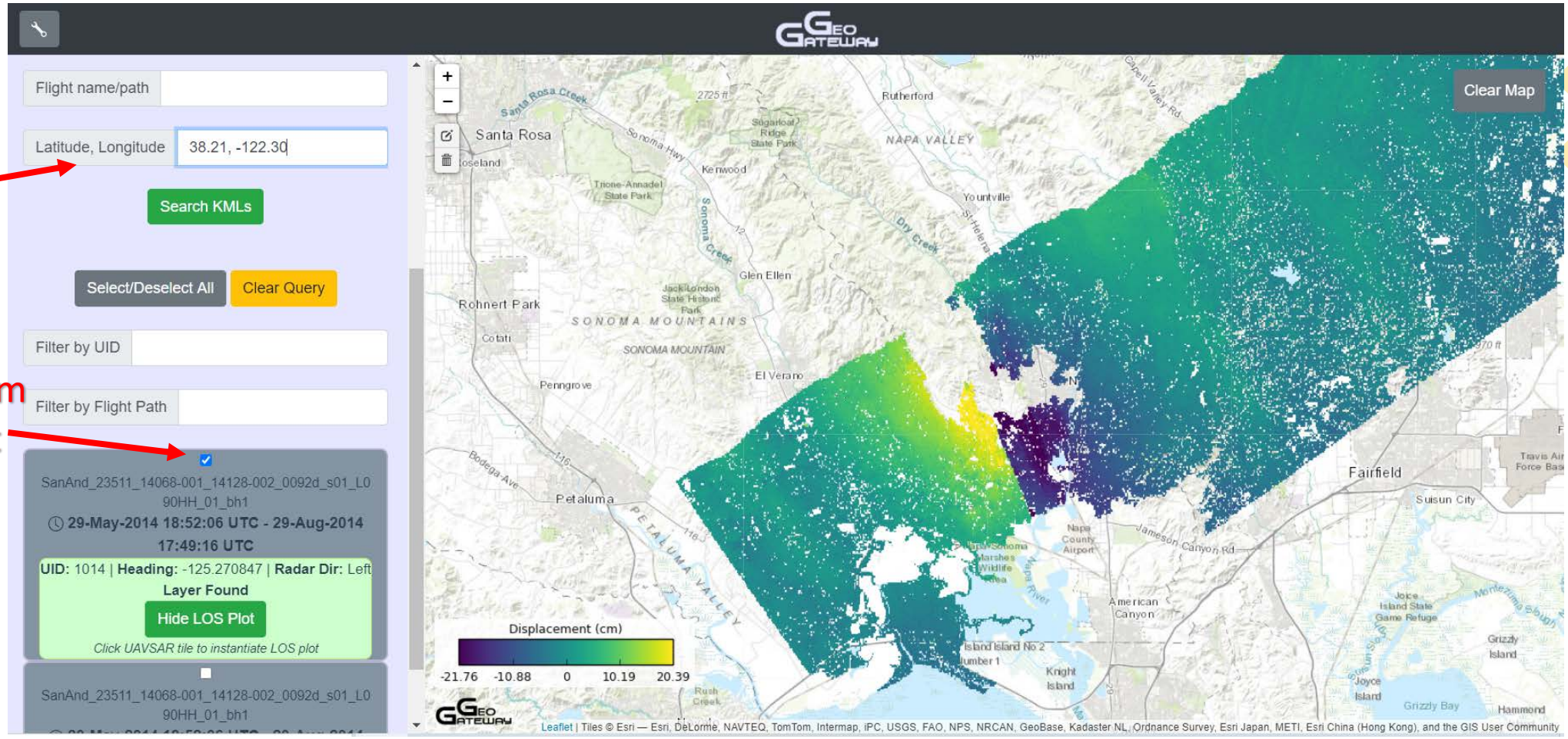
Select Interferogram of interest



Displaying Individual Lines

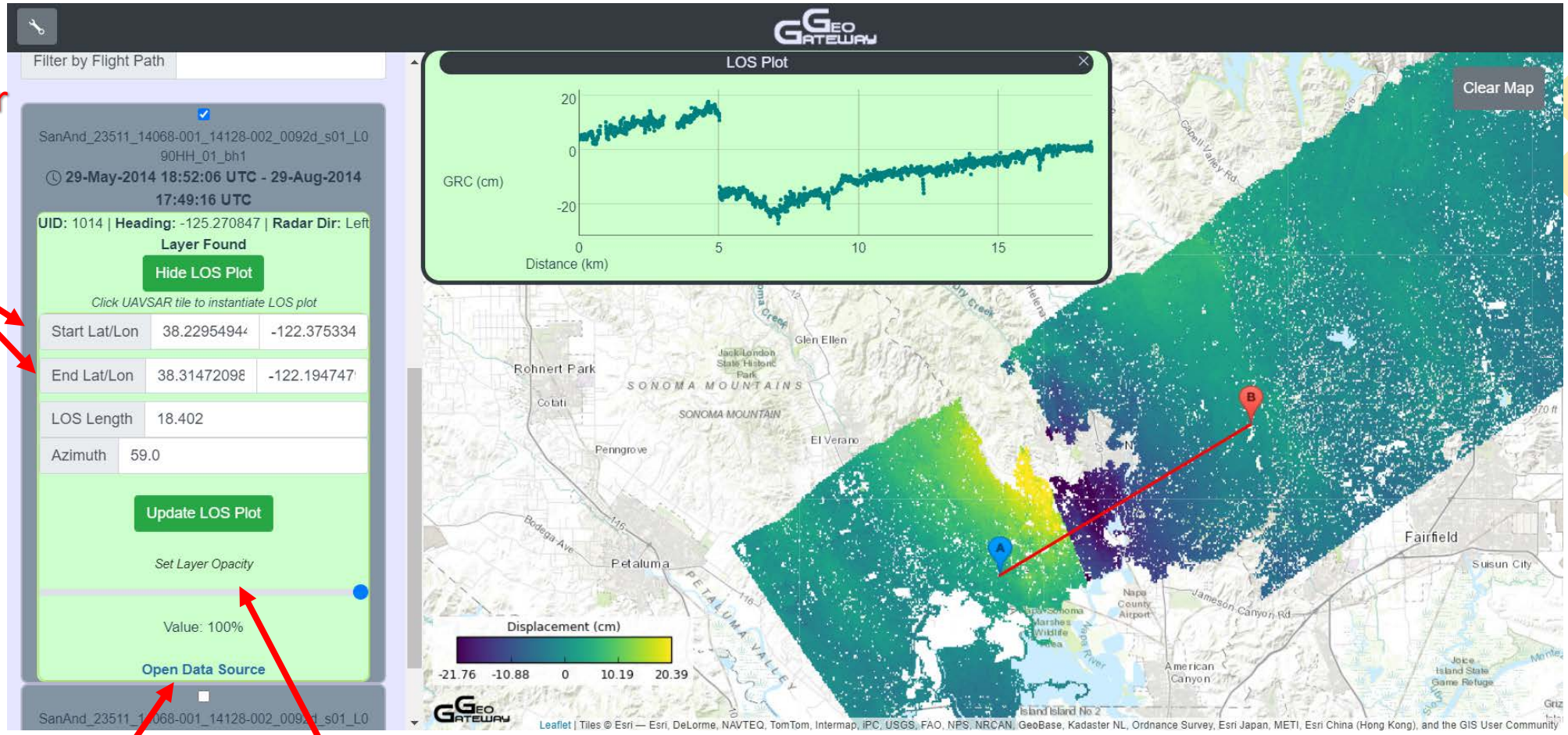
Select by Latitude & longitude

Click on interferogram of interest



Line of Sight Tool

Change parameters for interferogram start and end points



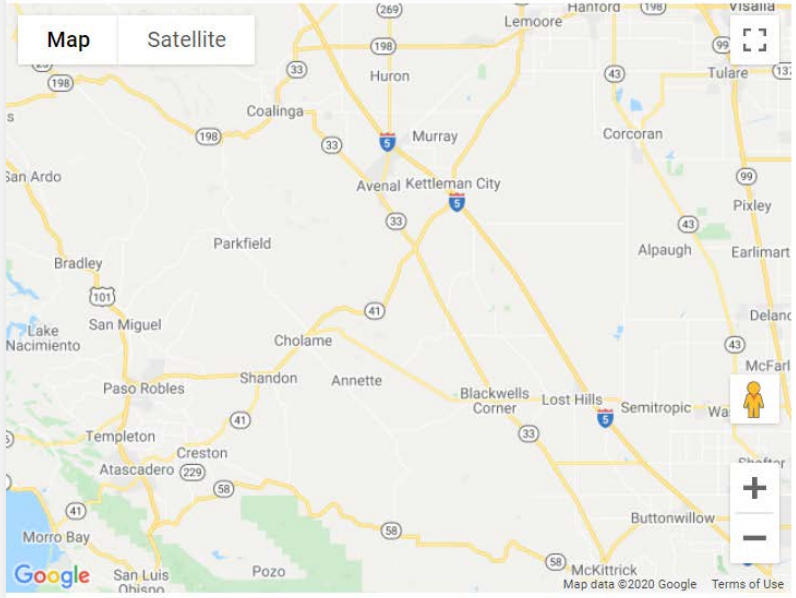
Download data

Set layer opacity

Downloading Products

SanAnd_26501_09083-010_10028-000_0174d_s01_L090HH_C2

- **Description**:San Andreas Fault - Salton Trough, CA
- **Time1**:21-Oct-2009 00:21:20 UTC
- **Time2**:13-Apr-2010 17:39:51 UTC
- **Lines**:6404
- **Samples**:20529
- **Terrain Height**:59.736268
- **GPS Altitude**:12495.0015
- **Peg Head**:-95.326483
- **Peg Lon**:-115.538897
- **Peg Lat**:32.903278
- **Radar Direction**:Left
- **Radar Wavelength**:23.840355



Data Source: NASA JPL Data Center

The NASA data archive at ASF now requires user login

Metadata

- Metadata
- Data format

Slant range Products

- Slant range interferogram
- Slant range unwrapped phase
- Slant range correlation
- Slant range amplitude 1
- Slant range amplitude 2

Ground range Products

- Ground range interferogram
- Ground range unwrapped phase
- Ground range correlation
- Ground range amplitude 1
- Ground range amplitude 2
- DEM used in ground projection

KMZ of Ground Range Products

- KMZ of Ground range interferogram
- KMZ of Ground range unwrapped phase
- KMZ of Ground range correlation
- KMZ of Ground range amplitude 1
- KMZ of Ground range amplitude 2
- KMZ of DEM used in ground projection

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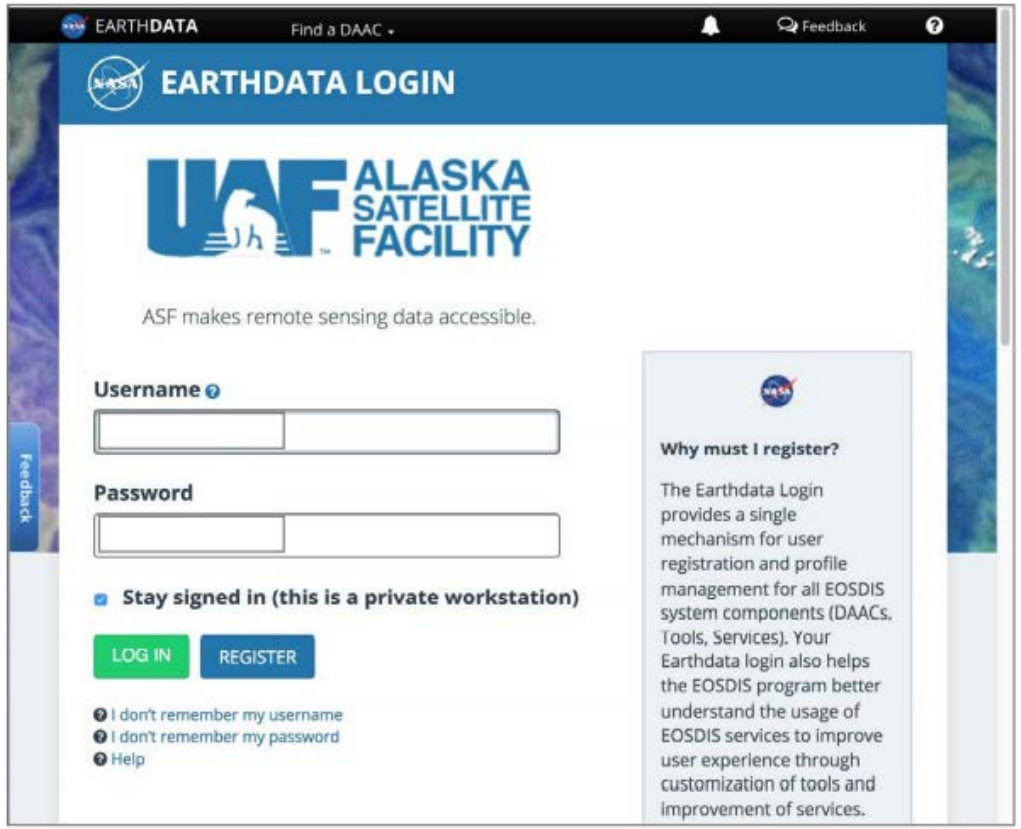
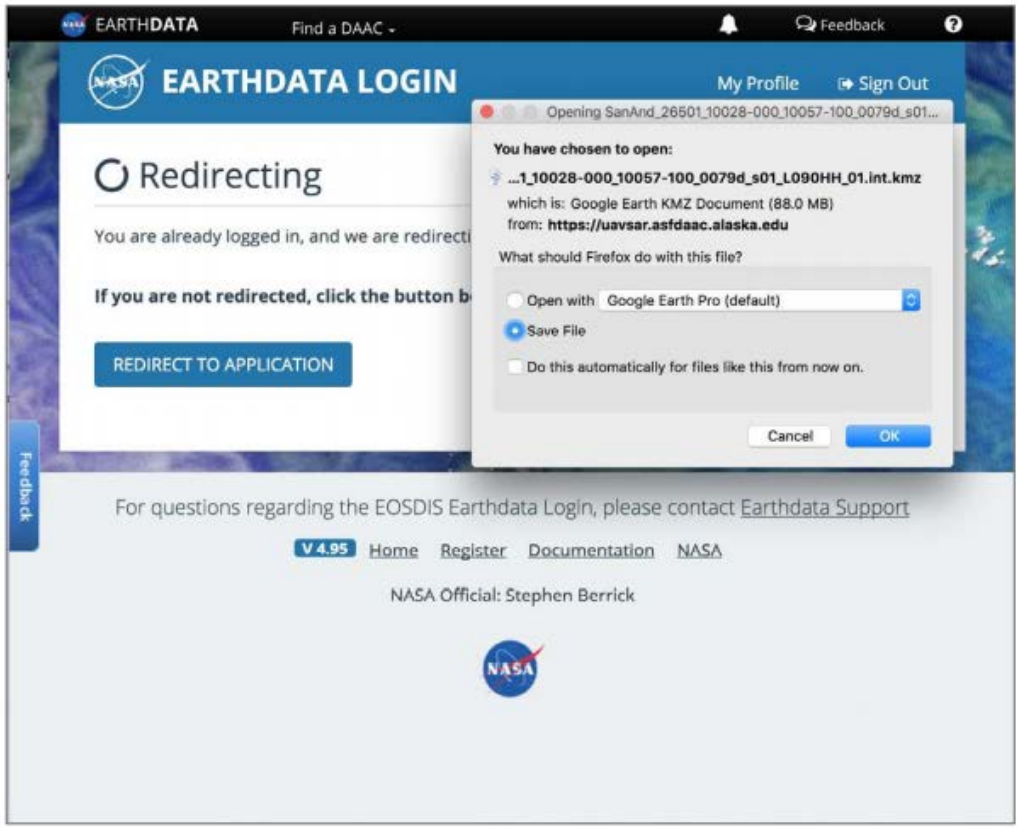
Downloading Products - UAVSAR





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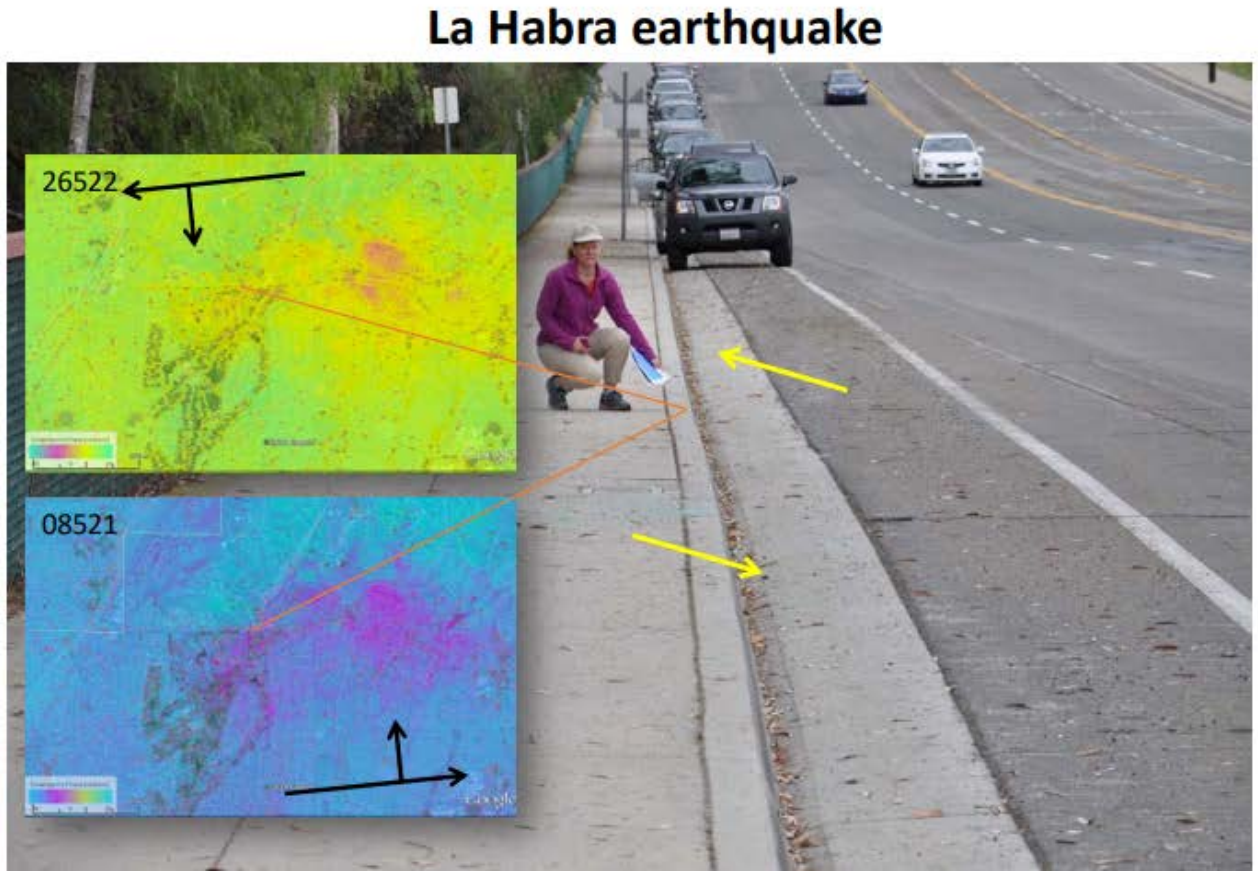
Location Awareness – Useful in the field

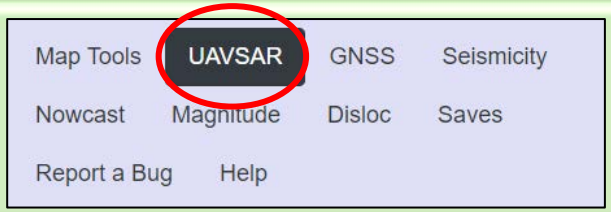
- Show location option under map tools is a feature that will be available shortly



UAVSAR - Example

Step 1: Visit website

Step 2: Click on the "UAVSAR" tab



Step 3: Check "show overview"

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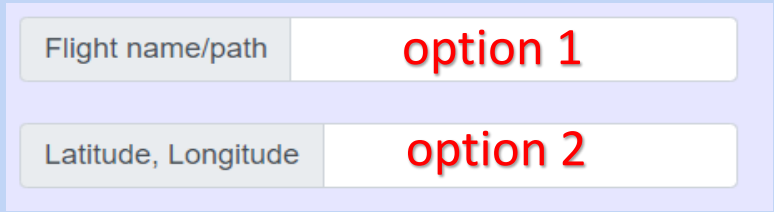
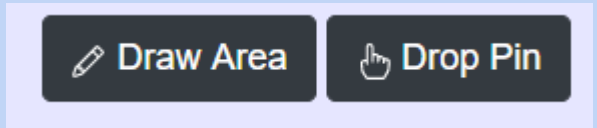
UAVSAR - Example

Step 4: Search for an interferogram (chose one of the following options)

1. The “flight name/path” directly finds the flight name and path wanted
2. The “latitude, longitude” option returns all flight paths crossing paths with those coordinates. In the case of this exercise, enter 26501 (flight name/path) in the search window and hit return

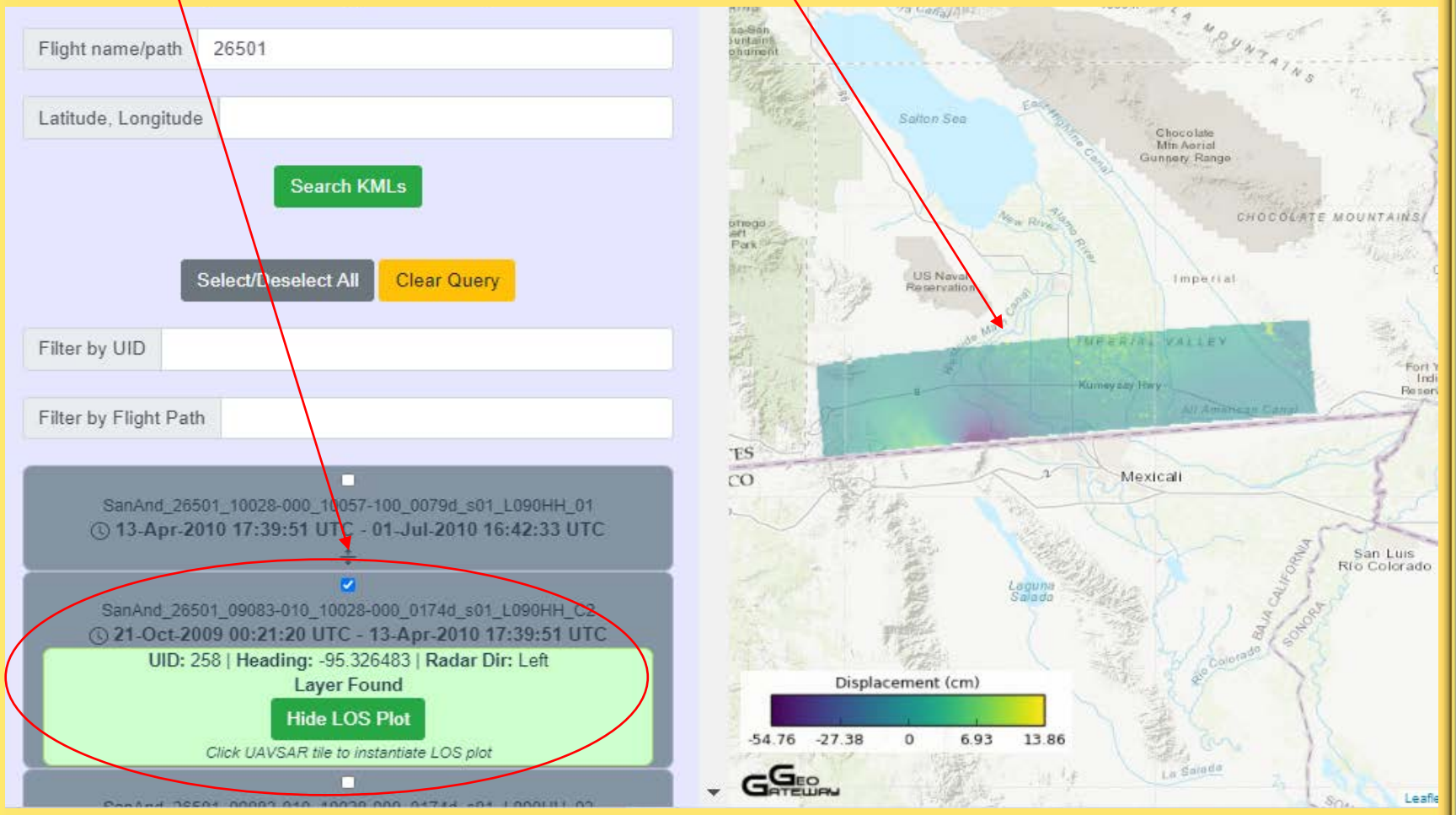


*Note options to draw an area or drop a pin can assist users to finding an interferogram



UAVSAR - Example

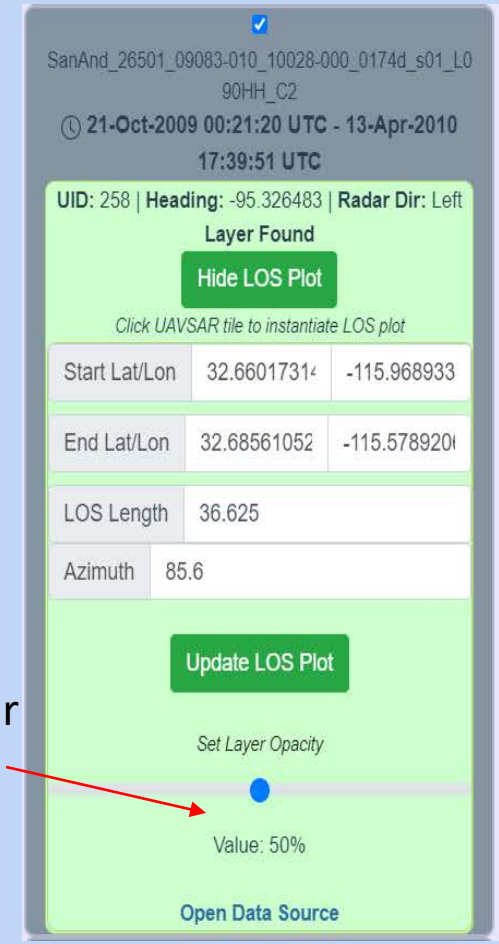
Step 5: Select the second interferogram & click on the interferogram shown on the map to activate the LOS tool.

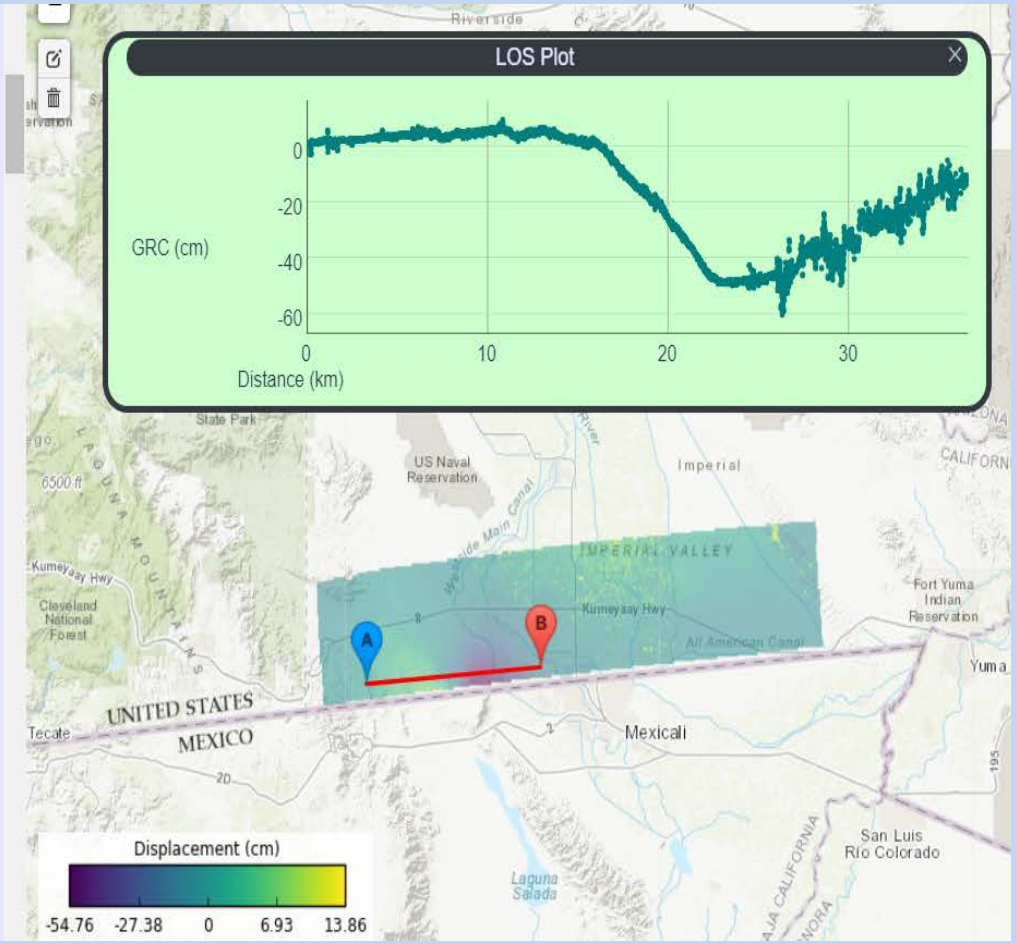


UAVSAR - Example

Step 6: Input the latitude and longitude for the starting (A) and ending (B) points for the LOS.

Note the “Set Layer Opacity” option, allows for users to increase or decrease the value for opacity of the interferogram.





Global Navigation Satellite System (GNSS) Tools

- EMC: Velocity
- Coseismic
- Postseismic
- Displacement
- Model
- Reference station
- Product download

GNSS Tools

Velocities
Coseismic
Postseismic
Displacement
Model

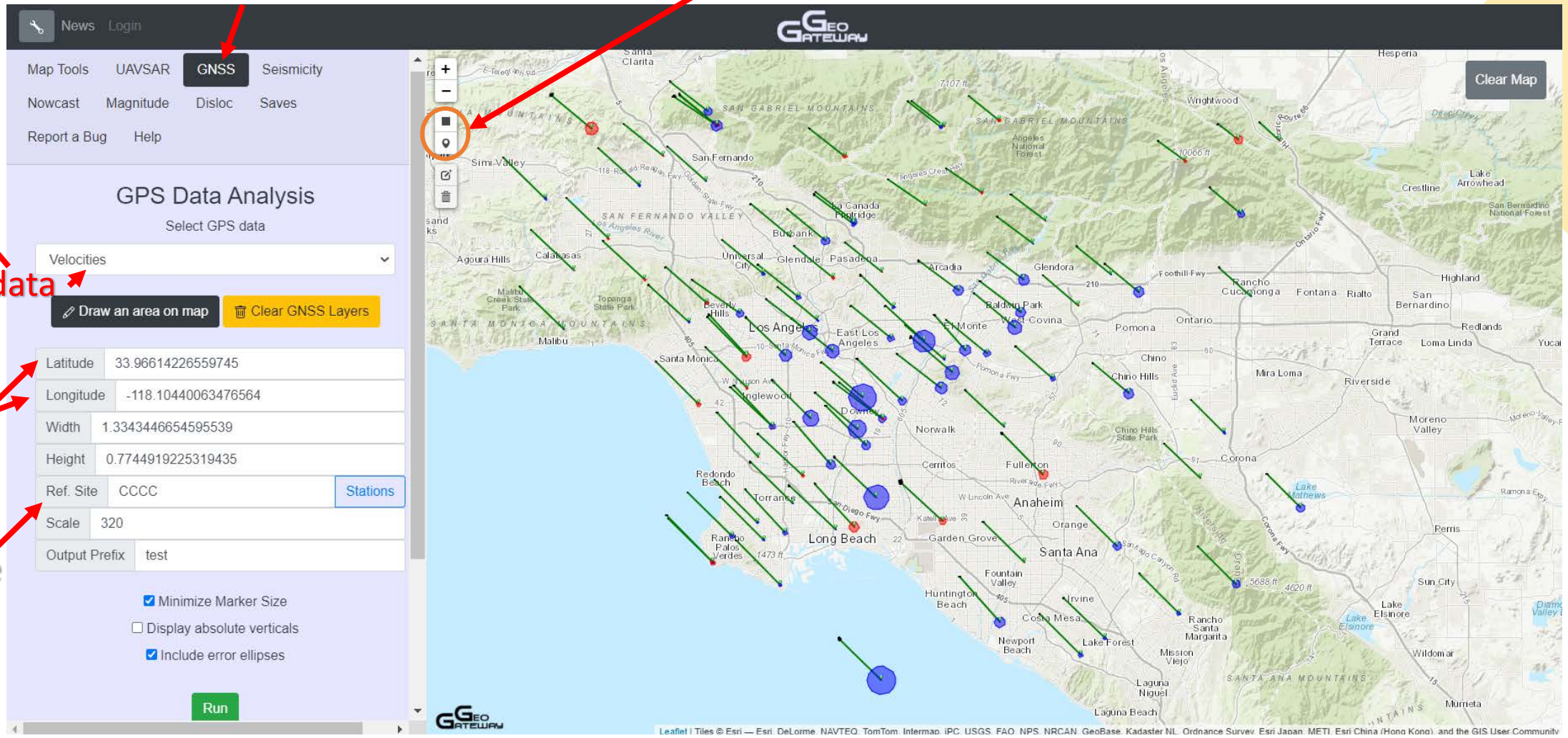
1. Click on GNSS tab

3a. Select by point or rectangle

2. Select GPS data

3b. Select by location

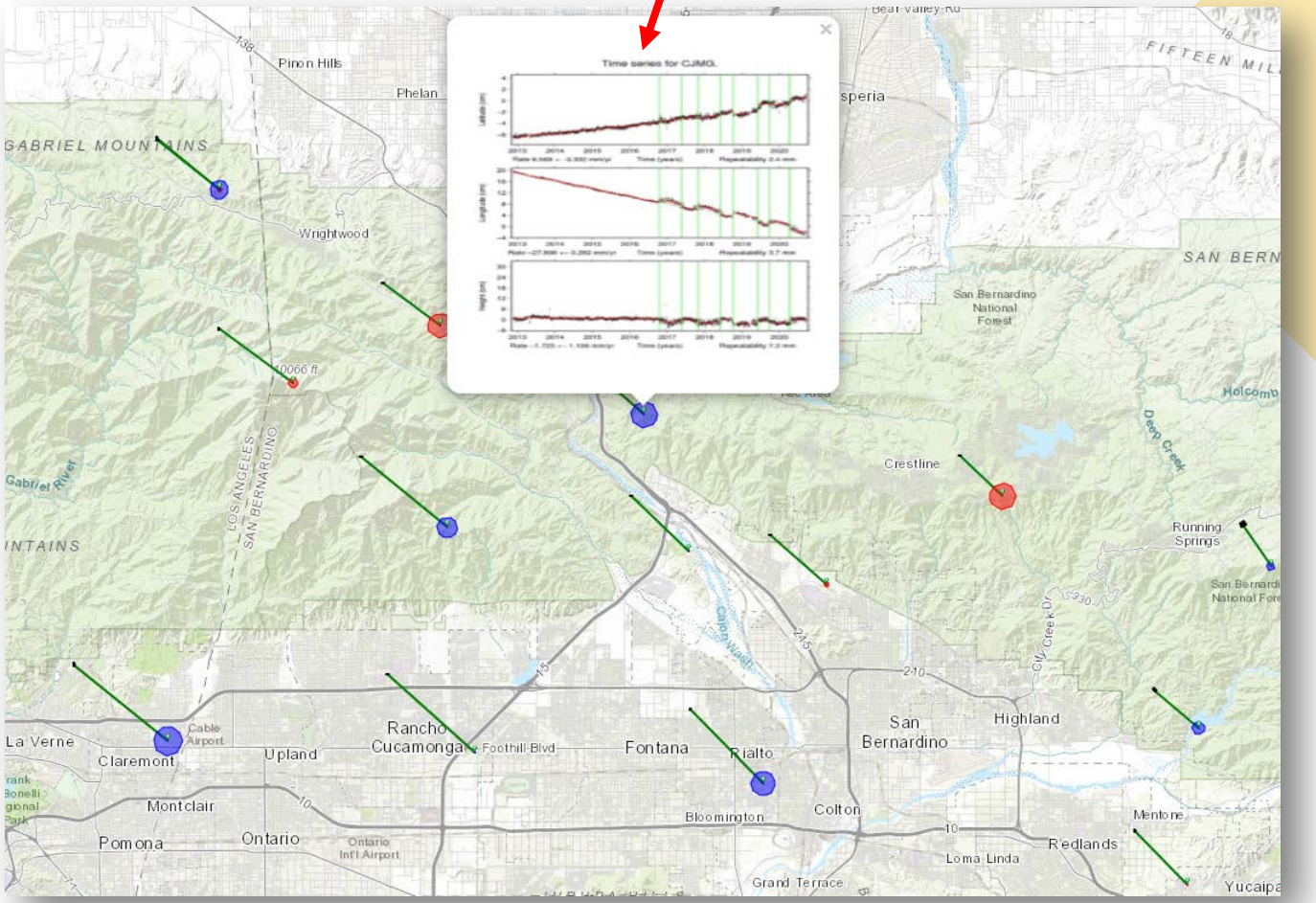
4. Reference site



GNSS Tools

- Each vector shows the velocity of a single GPS station
- Length of the vector shows how fast the GPS station is moving
- Vertical displacement is shown by red (uplift) or blue (subsidence) circles
- The larger the circle the greater the displacement

Click on a GPS station to view the time series' graphs

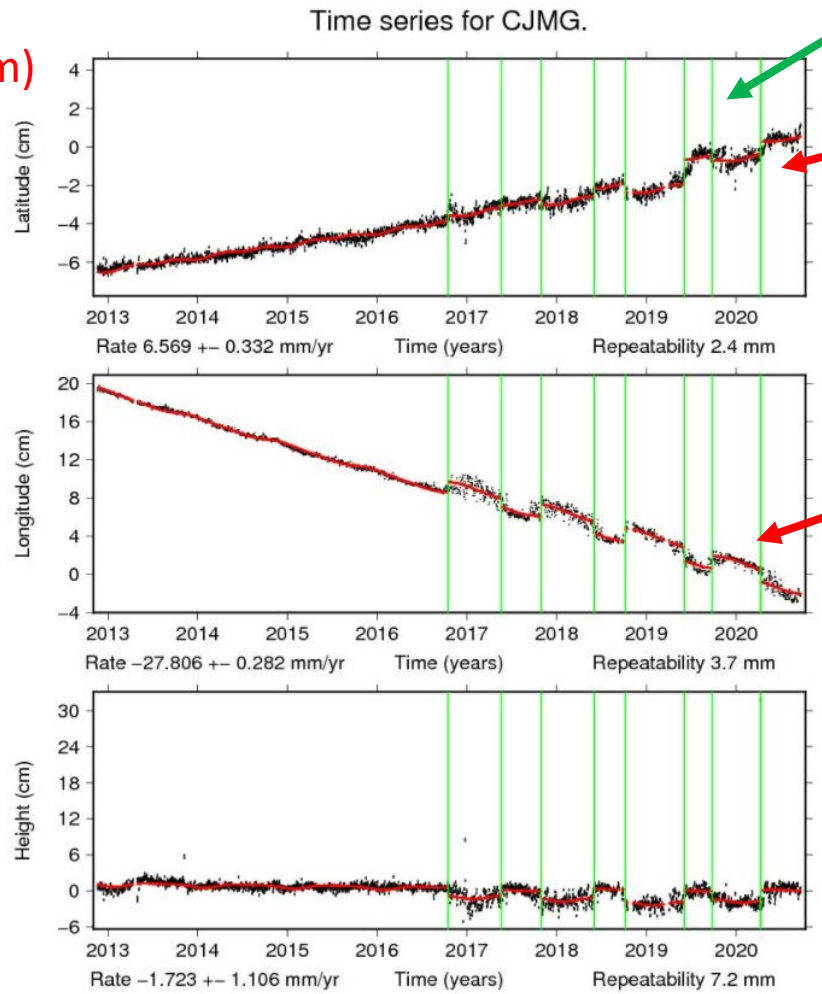


GNSS Time Series

top graph shows latitude (cm) versus time (years)

Middle graph shows longitude (cm) versus time (years)

Bottom graph shows the vertical height (cm) versus time (years) which is relatively constant



Vertical intersecting green lines are locations where there are jumps in the data

In the top graph, the station moves closer to the North with time

In the middle graph, the station is moving to the West with time

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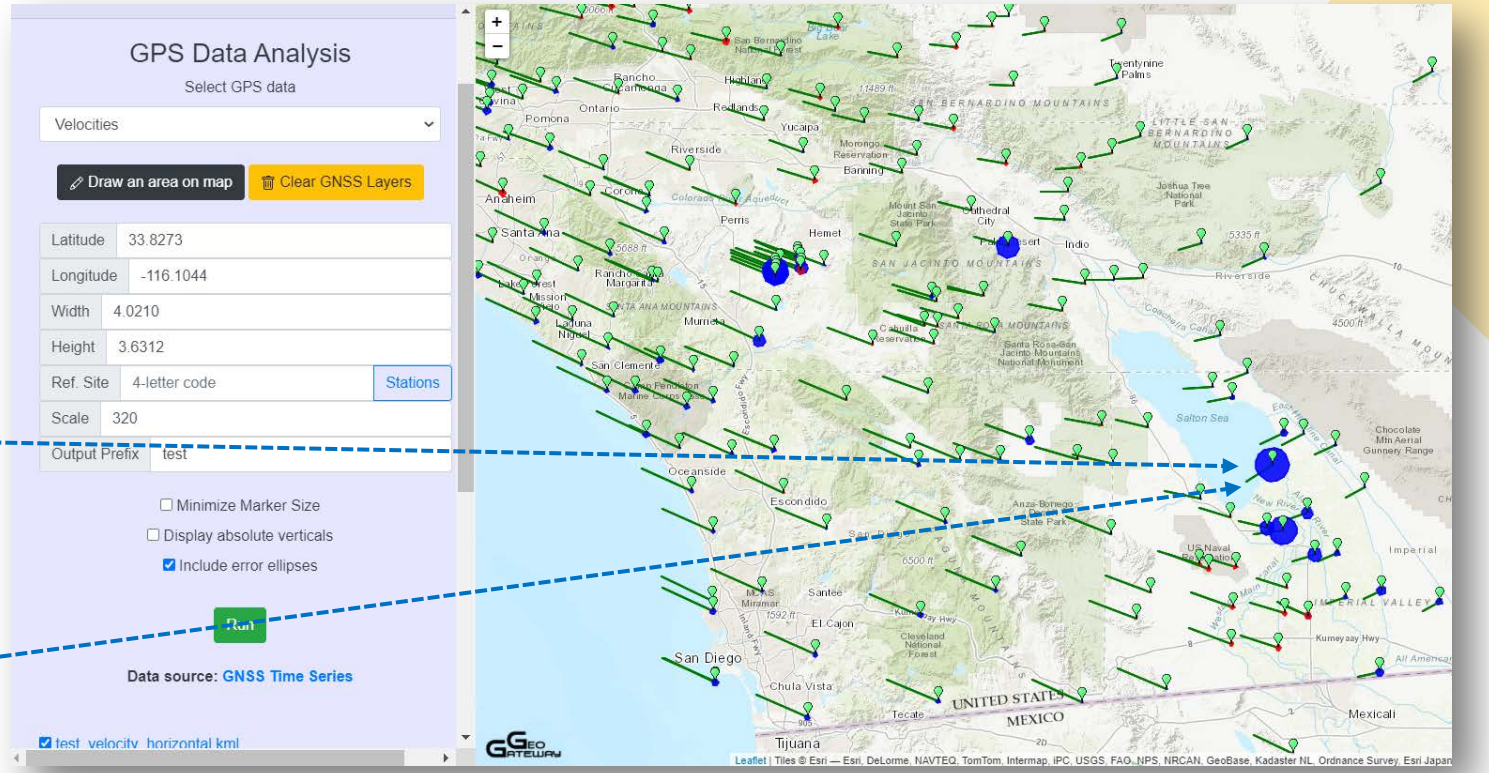
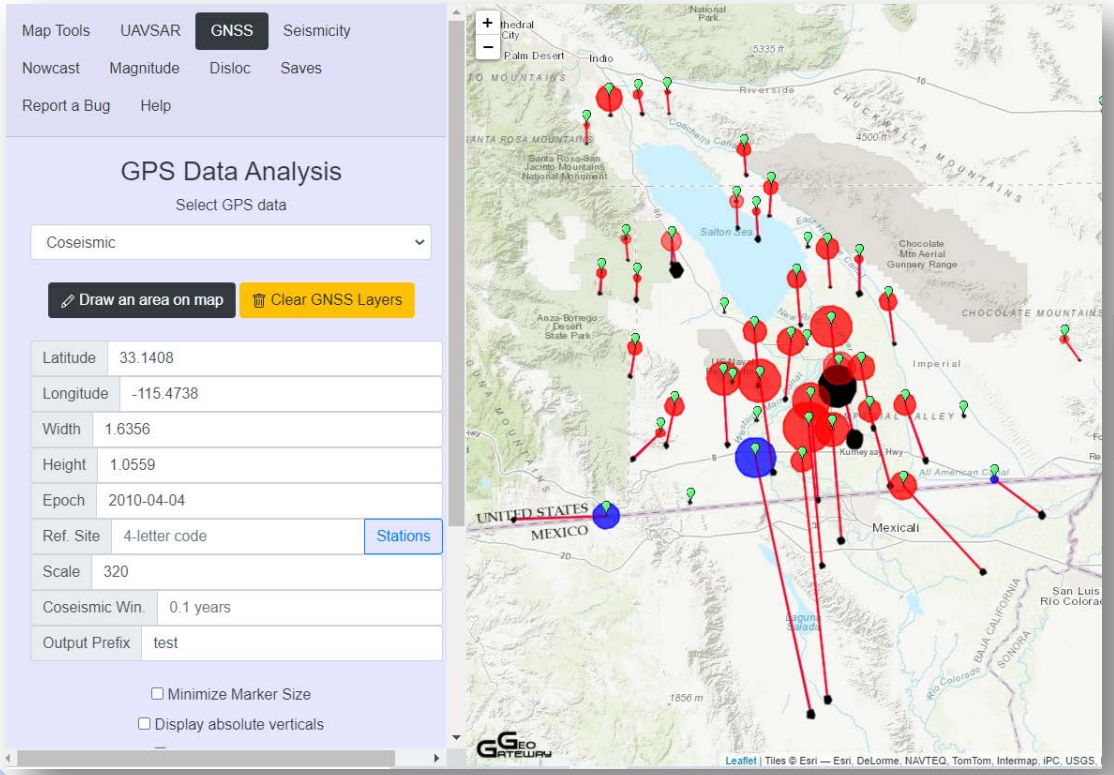
GNSS - Velocity

- The velocity vectors are shown as green vectors with error ellipses
- Vertical displacement is shown by red (uplift) or blue (subsidence) circles
- The larger the circle the greater the displacement

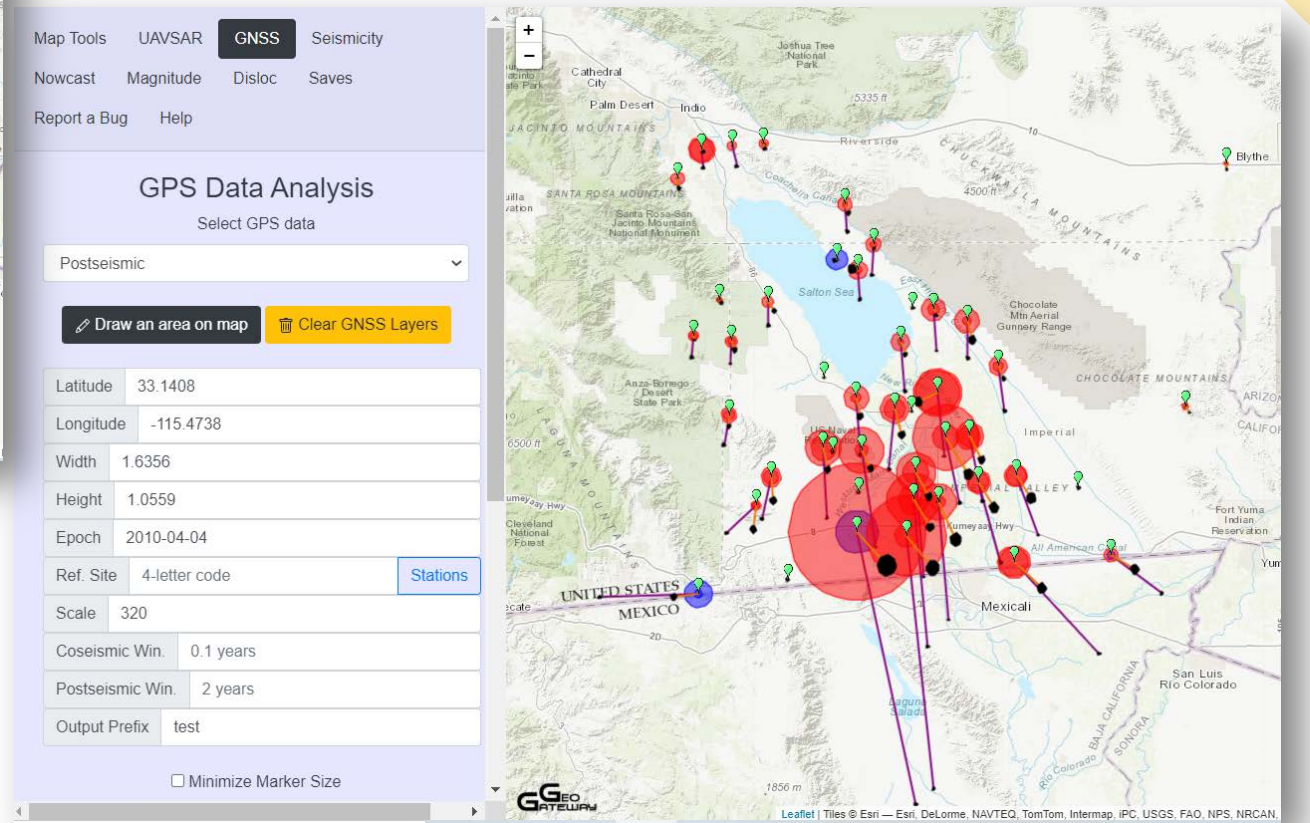


GNSS – Coseismic & Postseismic

coseismic

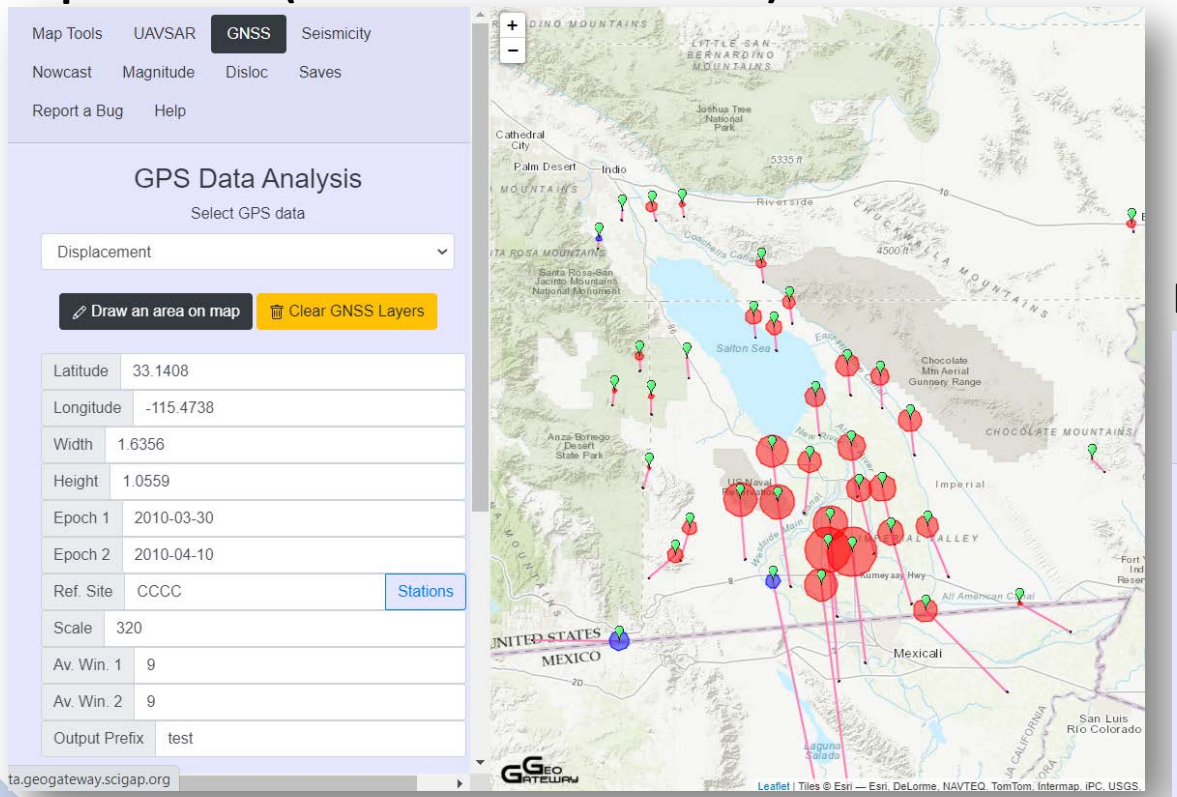


postseismic

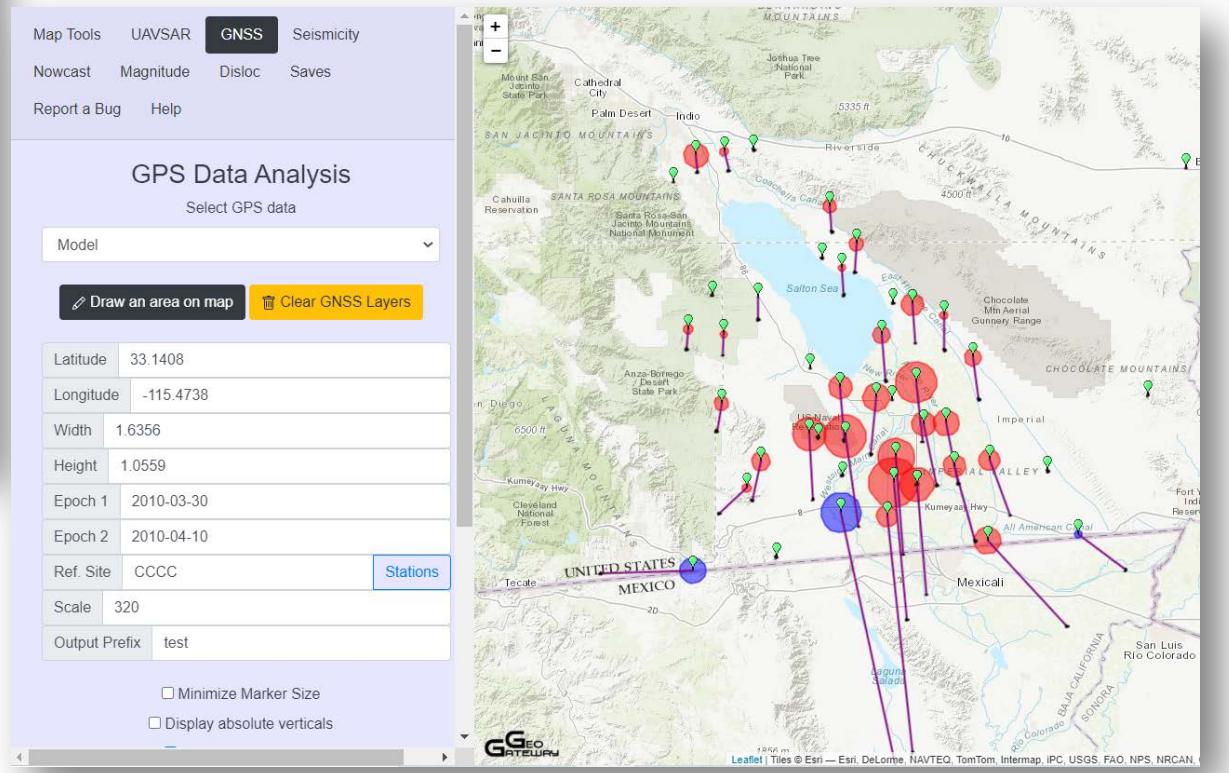


GNSS – Displacement & Model

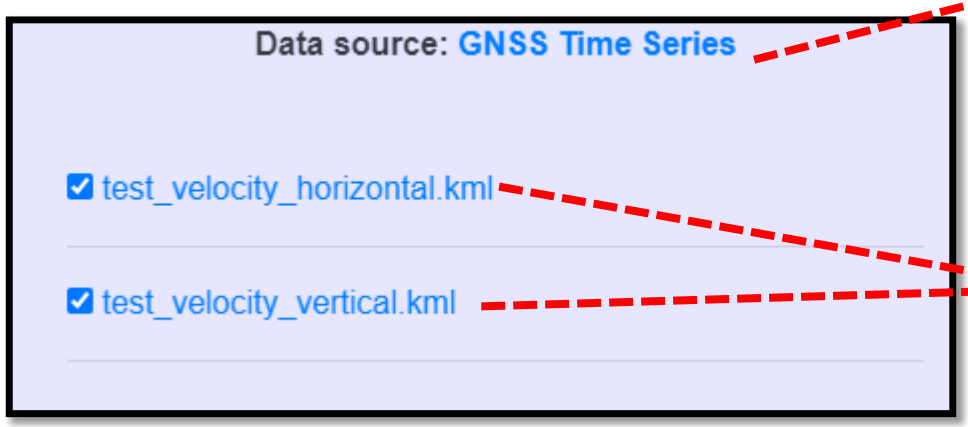
Displacement (alternative to coseismic)

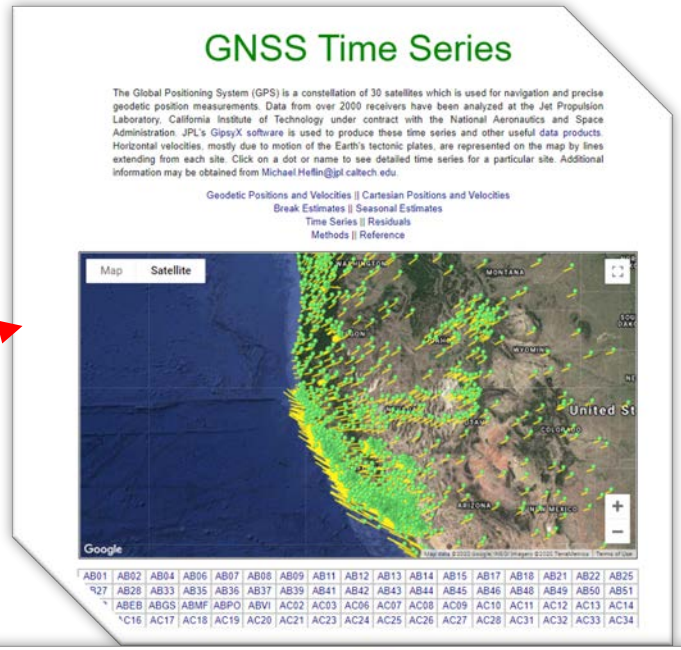


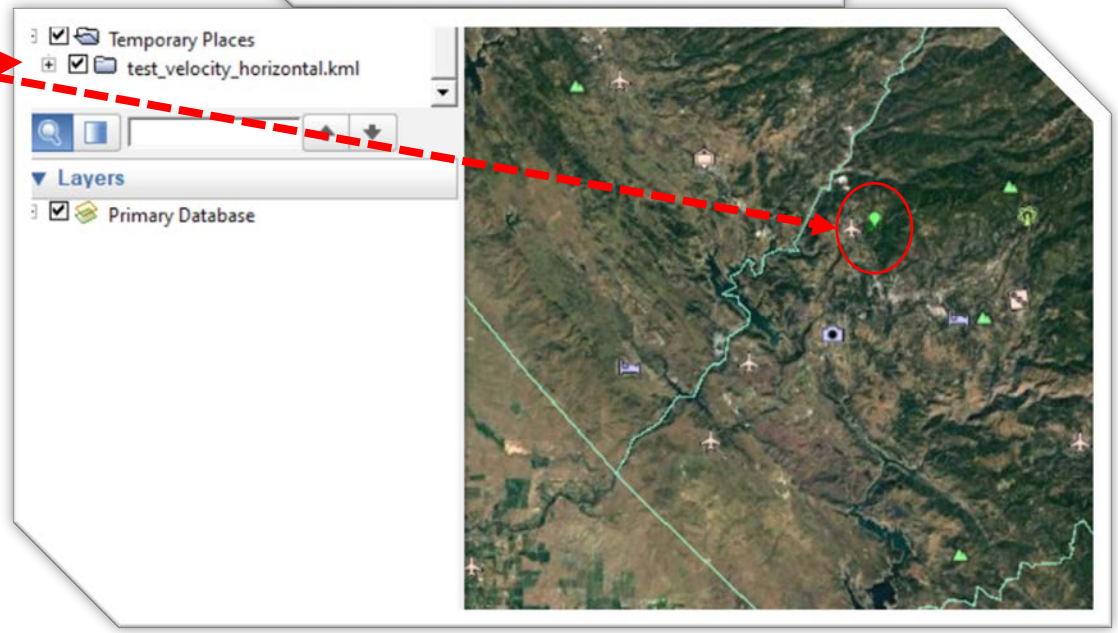
Model (alternative to coseismic)



GNSS –Download Data



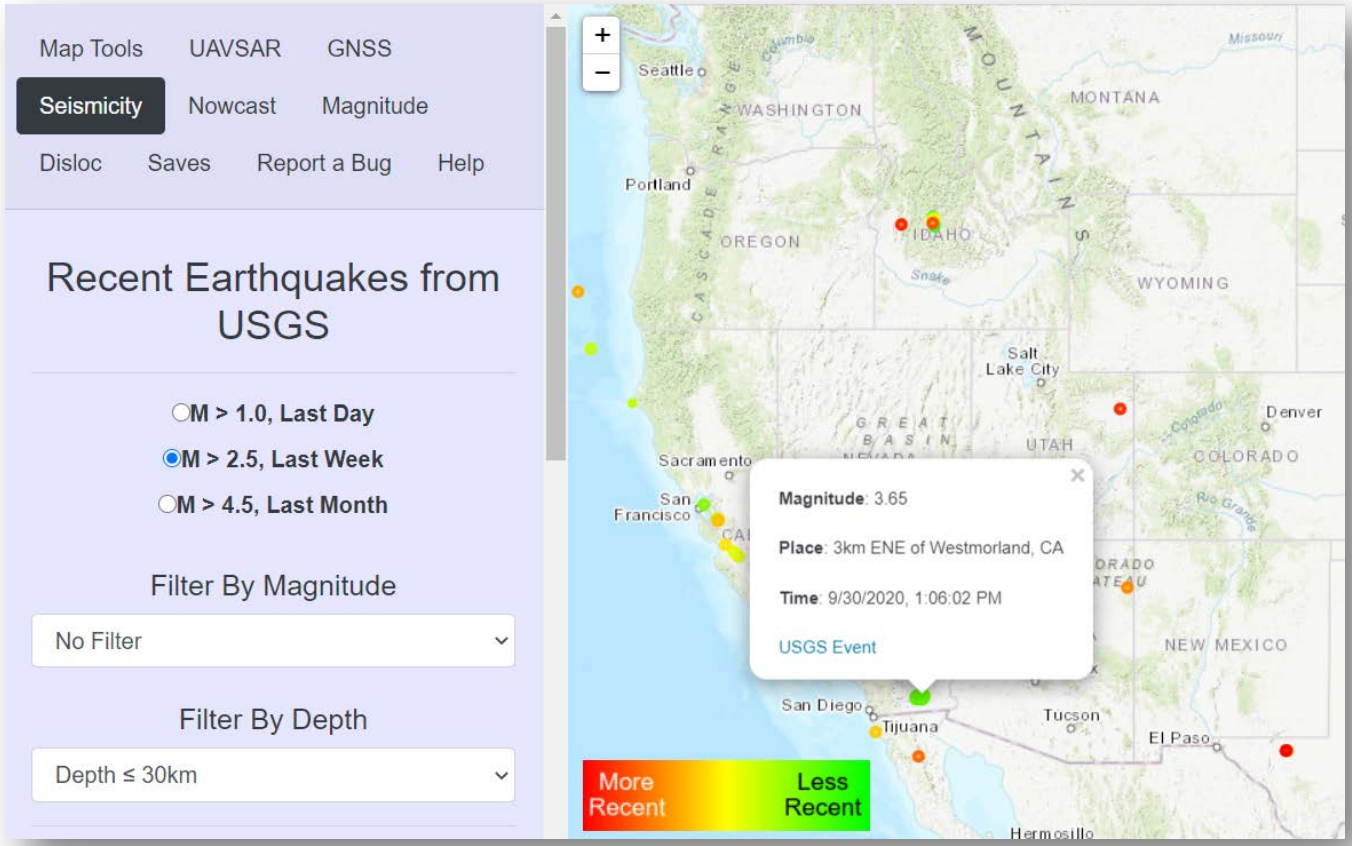




Seismicity

First Feature:

- Display seismic data from USGS feeds.
- Color coded for age of event, cooler colors for earlier events, hotter colors for later events.
- Event size corresponds to magnitude.
- Click on event for tooltips.



Seismicity

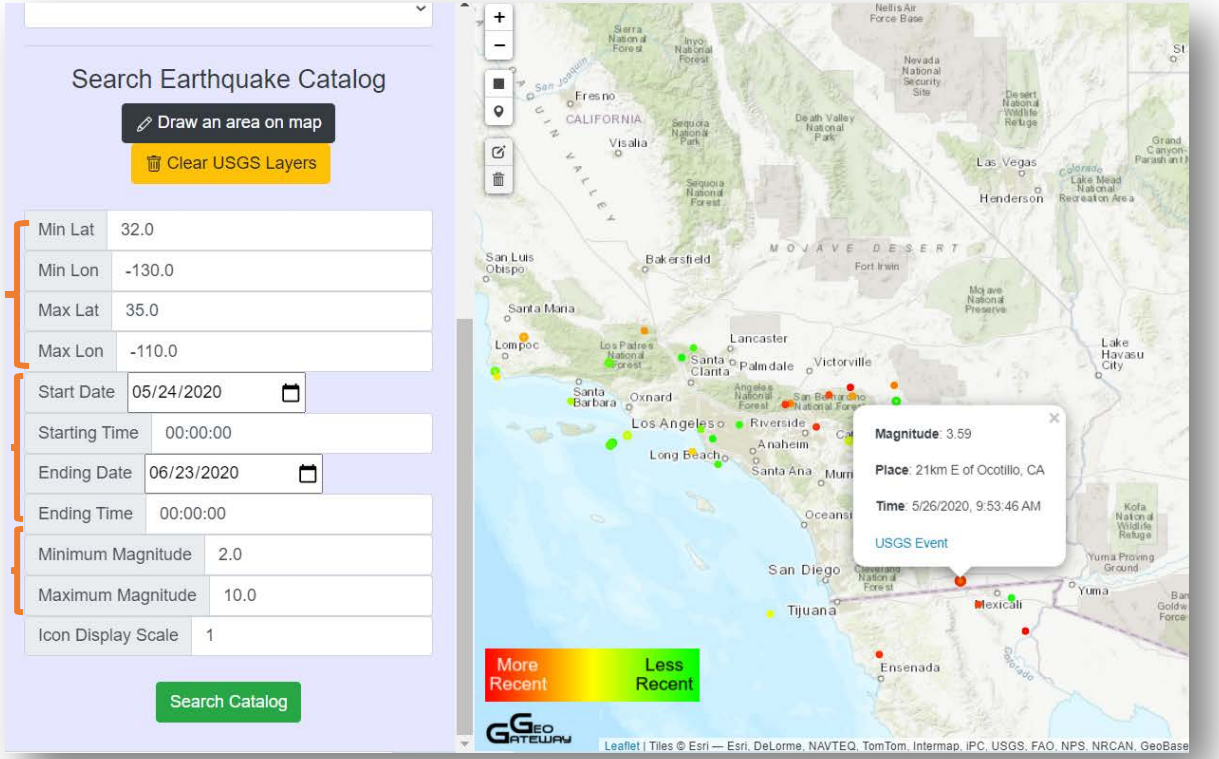
Second Feature:

- Filter to display seismic data from USGS feeds.

1. Insert latitude and longitude

2. Insert start and end date and time

3. Insert minimum and maximum magnitude

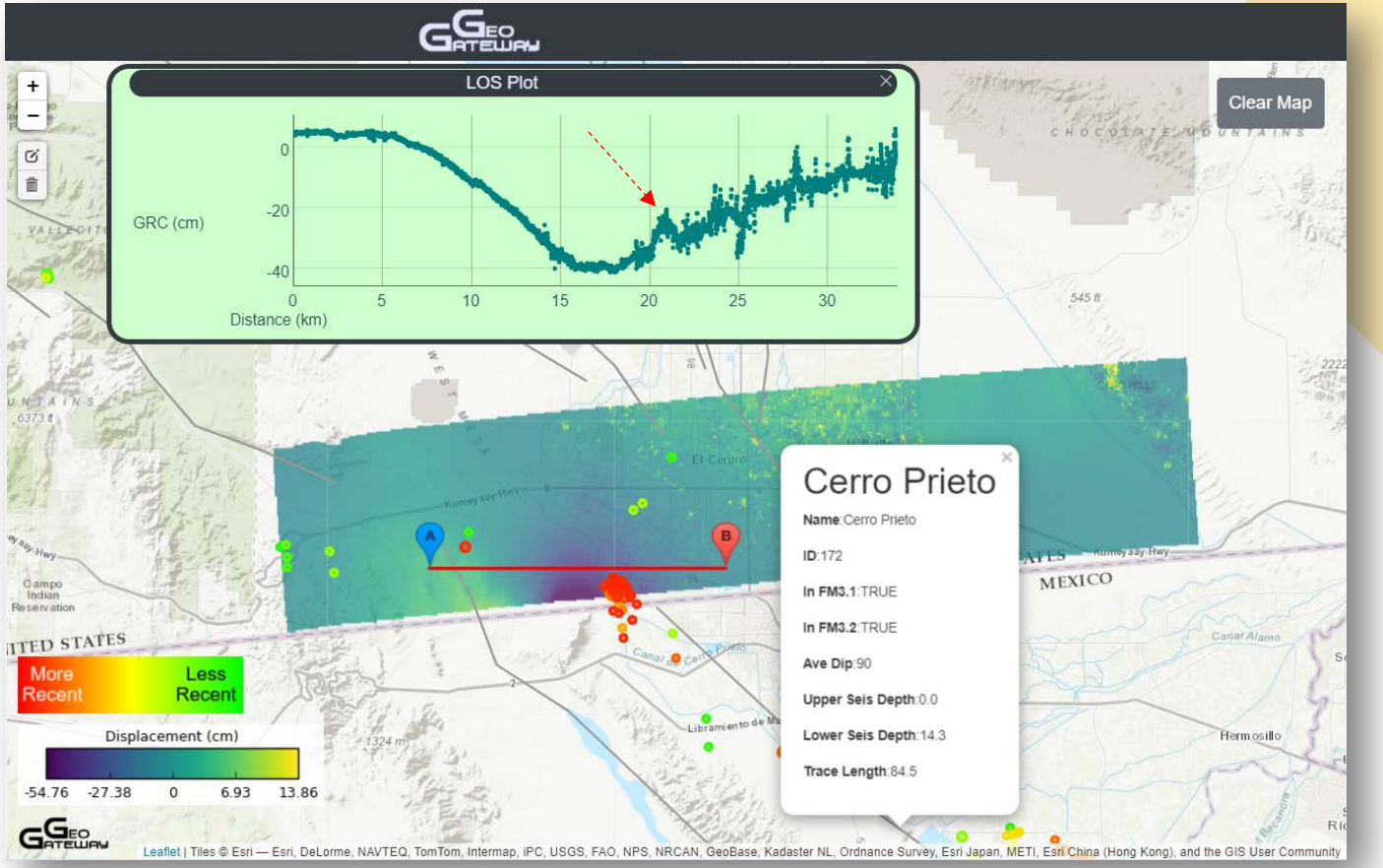


Multi-Method Layering (1-1)

- Method allows for users to explore the possible meaning of a feature in the interferogram that is not obvious at first glance.

- Figure displays
  1. UAVSAR
  2. Seismicity
  3. UCERF3 faults

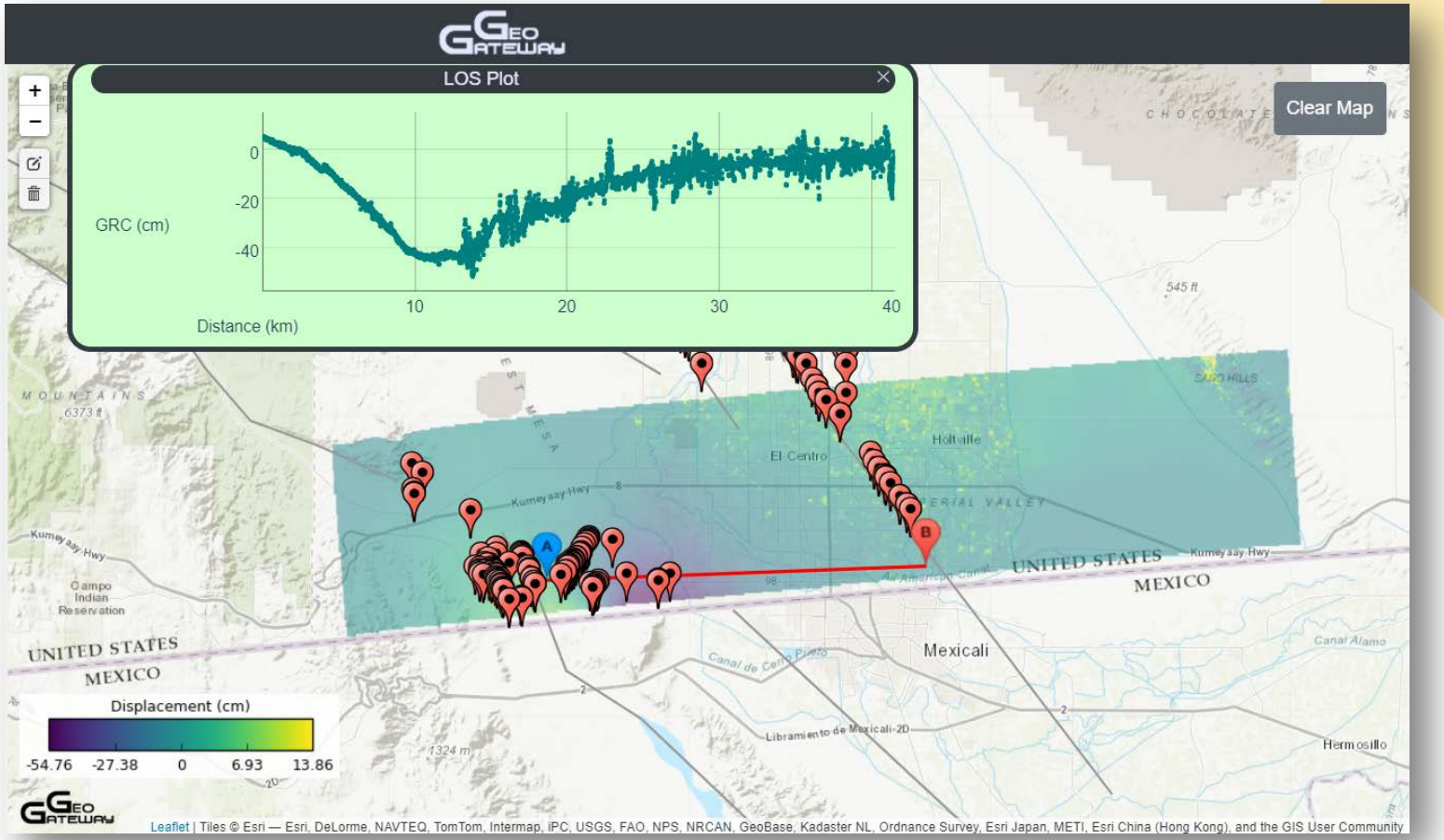
- Ground range change is shown to have occurred across the two lobes



Multi-Method Layering (1-2)

- Figure displays
  1. UAVSAR
  2. (kml file) slip data waypoints for the El Mayor-Cucapah earthquake[1]

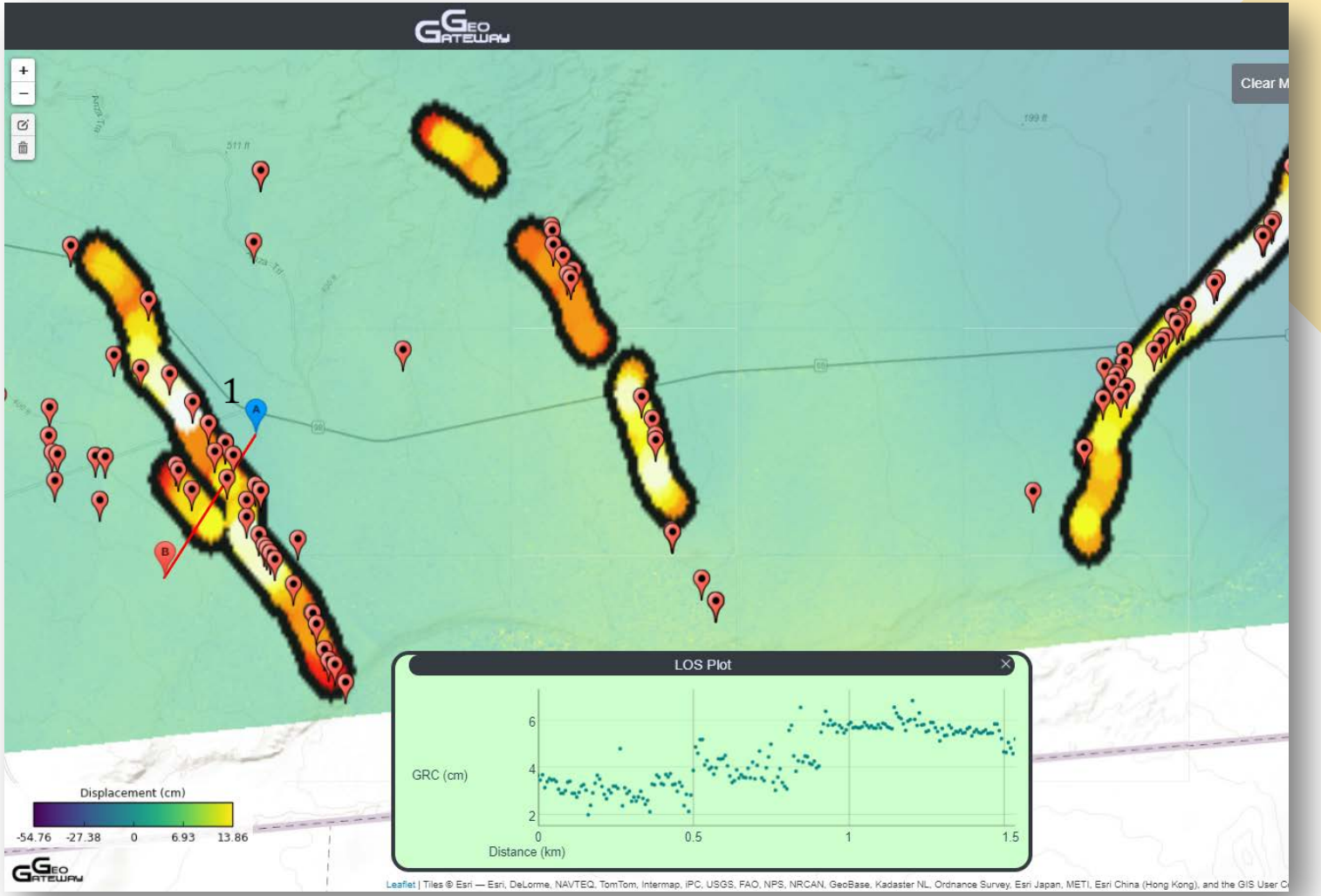
- The overlay, suggests surface fracture



Source(s): 1. USGS Open File Report 2010-1333

Multi-Method Layering (1-3)

- Figure displays
  1. UAVSAR
  2. Seismicity
  3. (kmz file) product of edge detection analysis
  4. (kml file) slip data waypoints for the El Mayor-Cucapah earthquake[1]
- Edge detection product is used to find surface fractures
- LOS profile shows the detection of two close “edges” or two upward jumps in phase (at distance 0.5 and 0.9 km)
  - Indicates two separate surface fractures in close proximity



Source(s): 1. USGS Open File Report 2010-1333

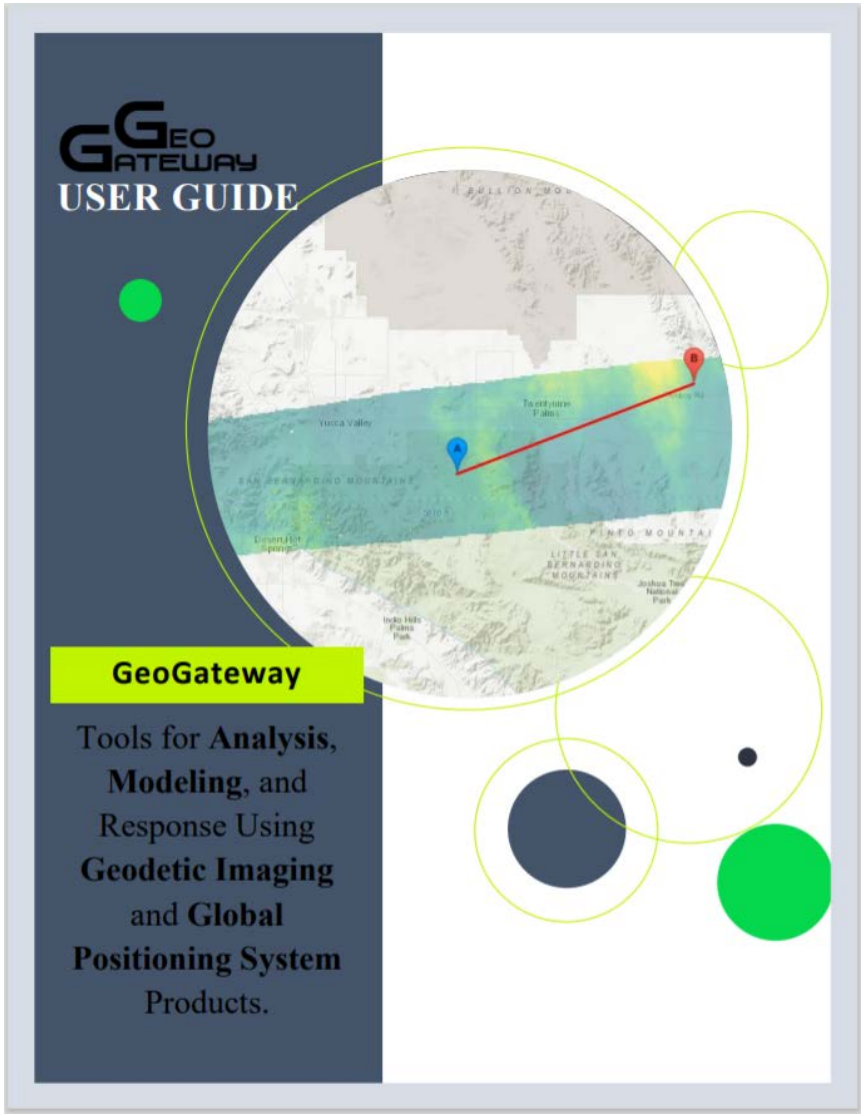
GeoGateway User Guide

Access website

- https://geo-gateway.org/
- **https://beta.geogateway.scigap.org/geogateway_django_app/**

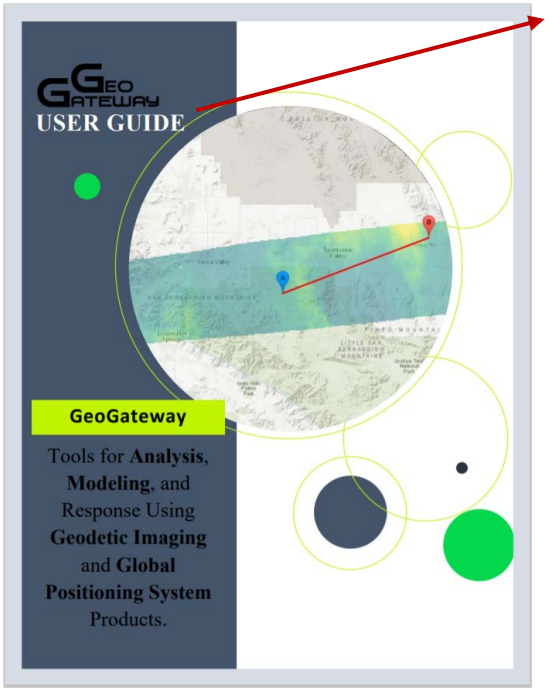
User Guide

- Presents and describes the hosted datasets and models accessible on GeoGateway.
- The User Guide allows for users to gain hands on experience through the inclusion of sample exercises to complete



Conclusion

- GeoGateway is a data product search and analysis gateway for scientific discovery, field use, and disaster response.
- GeoGateway focuses on NASA geodetic imaging products from InSAR and GNSS integrated with earthquake faults datasets, seismicity, and models.
- Note that GeoGatway offers additional tools and functions available on the website as illustrated on the “Table of Contents” page from the user guide.



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Thank you